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AD-A224 859

# Phase I Sediment Engineering Investigation of the Caliente Creek Drainage Basin

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Sacramento District  
US Army Corps of Engineers

June 1990

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## Executive Summary

This report presents the results of the second of two elements of a Phase I Sediment Engineering Investigation (SEI) conducted for the Sacramento District Corps of Engineers. Results from the first element of the SEI are reported by Harvey (1989). He presents the results of a Geomorphic Analysis of the Caliente Creek drainage basin. The present report presents the results from the Sedimentation Analysis conducted by the Hydrologic Engineering Center (HEC) which is intended to expand on previous work done by the Corps (USACE, 1988-b) in order to better estimate the average annual sediment yield at the proposed damsite and to also estimate potential single event sediment volumes for various frequency based storms.

The Hydrologic Engineering Center reviewed available scientific and engineering literature pertaining to methods for estimating sediment yield and evaluating sediment transport processes on alluvial fans. HEC conducted a three-day field reconnaissance and sediment data collection investigation, interviewed persons familiar with the Caliente Creek Project and watershed, and conducted a series of sediment engineering analyses to determine the possible sedimentation (scour, deposition, transport) characteristics of the drainage basin and alluvial fan near the proposed damsite.

The average annual sediment yield at the proposed damsite was estimated using results from eight different sources of data and/or methods for estimating sediment yield. Sediment engineering methods presented in the Sediment Engineering Manual, EM 1110-2-4000 (USACE, 1989) were used throughout this investigation. Other methods prescribed by the Soil Conservation Service (USDA, SCS, 1975, 1977, 1980) were also applied. The following procedures were used: (1) Previous reports and publications were thoroughly reviewed for information and data pertaining to the study, (2) USDA (1977) published reservoir sedimentation rates were examined, (3) recent USACE reservoir sedimentation survey data were analyzed, (4) sediment yield maps for the Western United States (USDA, SCS, 1975) were examined, (5) the average annual sediment yield was estimated from computations of the total event sediment volumes for single events ranging from the 2-year event up to the PMF based on channel transport capacity rather than annual watershed sediment production and delivery, (6) a similar flow duration and sediment load curve integration method (see EM 1110-2-4000, USACE, 1989) was used to estimate the average annual sediment yield to the reservoir site, (7) the Pacific Southwest Inter-Agency Committee (PSIAC, 1968) method was used to estimate basin-wide sediment yield from the entire watershed, and (8) the Dendy and Bolton (1976) Regional Analysis Method for sediment yield was applied.

The estimated annual sediment yield compiled by this study ranged from 0.2 AF/sq mi/yr to 2.2 AF/sq mi/yr. Based on results from past studies, recent reservoir surveys and computations performed during the present study, including the consideration for the geomorphic characteristics of the watershed, the average annual sediment yield at the proposed Sivert damsite is estimated to be approximately 0.75 AF/sq mi/yr. This represents approximately 353 acre feet of dry sediment per year in the form of annual removal

requirements. Extrapolated out linearly for the life of the project, this represents approximately 35,300 acre feet of removal requirements. Because of the episodic nature of the basin the annual sediment yield may be significantly higher than .75 AF during high runoff years. For instance, one 100 year event may deliver approximately twenty times the average annual amount of sediment within a one week period. Conversely, the yield can be lower during dry periods.

Sediment transport in the basin is episodic and depends largely on the occurrence of large events. Sediment is stored in the broad valley washes (approximately 3000 to 6600 feet wide) in the lower portions of the Caliente Basin. There is sufficient material located in these expansive washes to supply sediment to the lower fan areas somewhat independently of the production and delivery of sediments from the upper watershed areas. Therefore, sediment yield at the proposed damsite may be more dependent upon the transport capacity of the channels and washes immediately upstream from the damsite than the basinwide (watershed) production of sediment materials during a flood event. Single event floods can produce significantly more sediment per event than the estimated annual sediment yield per year. As much as 43 percent of the total gross pool storage volume (16,000 AF) could be lost due to sediment deposition during a one percent chance (100 year) flood event. This would necessitate the removal of approximately 6,900 AF (11,320,000 yd<sup>3</sup>) of sediment material from the reservoir prior to the next flood season. Removal of this amount of mud and debris during one summer season by using traditional removal methods (rubber tire loaders and trucks) may be difficult without dewatering the material first or by applying other special removal methods.

Examination of the sedimentation characteristics of the Caliente Creek basin has raised additional concerns with respect to the presently proposed (i.e., feasibility) J-shaped plan for the dam and reservoir. The proposed reservoir design requires concentration of the flows along the toe of the high Sand Hills (along the western margin of the lower Caliente Creek incised fan). Past floods (1983) have caused erosion of portions of the toe resulting in mass failure of at least two sections of the Sand Hills onto the floodplain. Concentration of future flood flows along the toe of the Sand Hills may lead to the failure of large sections of the high bank materials and significantly increase the sediment volume entering the reservoir during an event, thus decreasing the water storage capacity. Soils stabilization and grouting along the Sand Hills abutment section may be necessary. Stabilization and special treatment of the spillway apron and thorough protection of the east side of the J-shape dam embankment section adjacent to the spillway chute is necessary to prevent spillway and embankment erosion problems.

Active faults (White Wolf and Breckenridge faults) traverse the basin and have caused significant mass wasting in the upper watershed in the past (e.g., the 1952 earthquake). The Caliente Creek drainage basin and proposed damsite are located within seismic zone 4 where the possibility for large earthquakes is great (USACE, 1988-a). Possible mass wasting of the high Sand Hills into a full or partially full reservoir may displace (via overtopping) a large amount of stored water out of the reservoir and onto downstream portions of the fan. Within this scenario, failure of the dam embankment due to overtopping is possible. Dam safety analyses may be required during future (Phase II) studies.

The proposed reservoir design requires water to back up in the pool and into the spillway approach channel for the spillway to function. Closure of the eastern highway opening (under Highway 58) and the installation of a setback levee on the floodplain upstream from the spillway apron is necessary to preclude flow short circuiting directly into the excavated spillway outlet. Installation of these measures places more hydraulic pressure and shearing stresses on the remaining western opening under Highway 58 and onto its earthen embankment as well. Additional detailed hydraulic and scour computations should be conducted during the phase II SEI studies.

Field methods exist that allow circumstantiation of the estimated annual yield values. Time and cost estimates are being prepared for conducting such a circumstantiation investigation as part of the Phase II SEI.

# **Phase I Sediment Engineering Investigation of the Caliente Creek Drainage Basin**

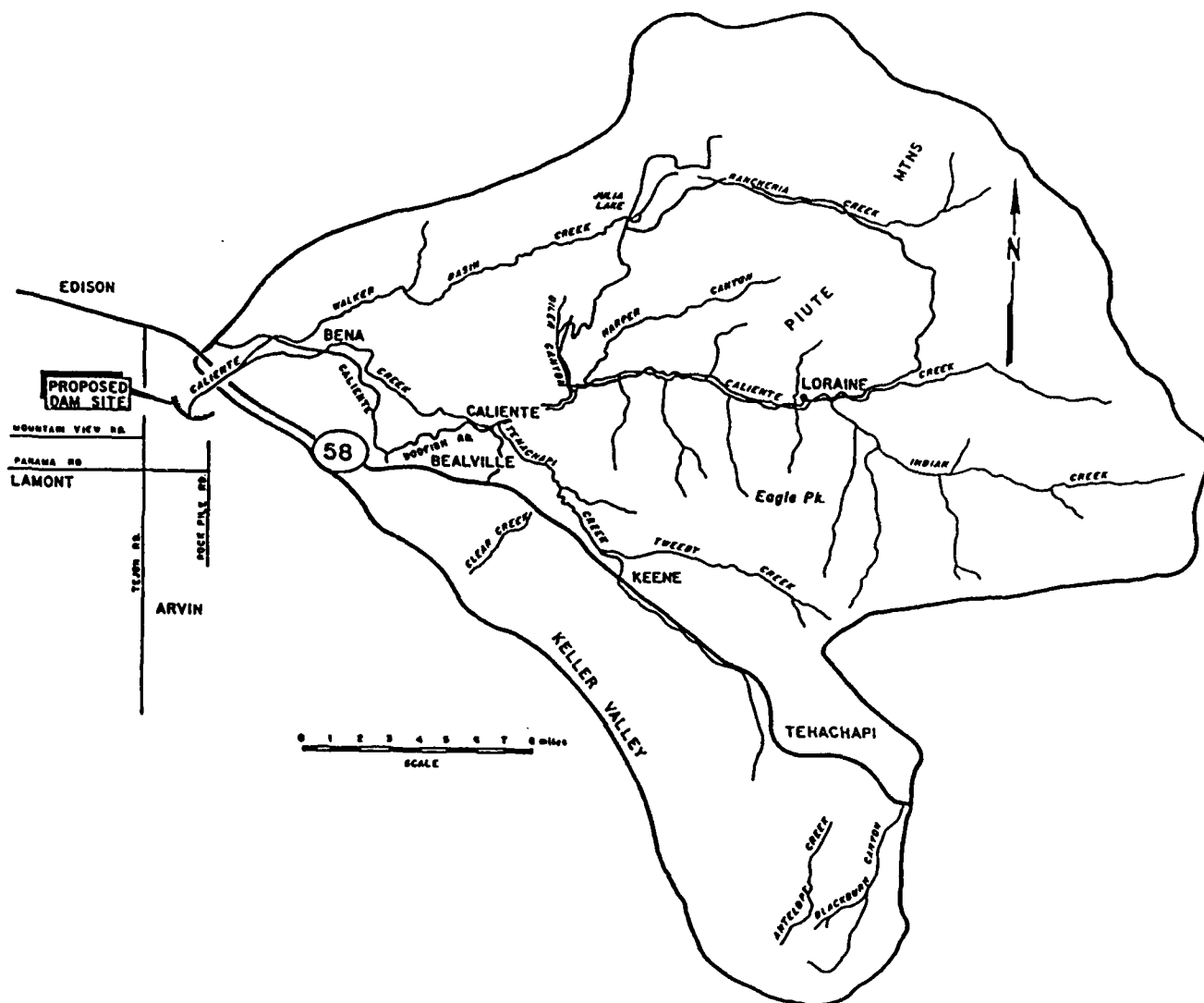
## **1. Study Purpose**

The proposed Caliente Creek Flood Control Project is in the feasibility (planning) phase, and consists of a flood detention reservoir to be built on the Caliente Creek alluvial fan approximately two miles downstream from Highway 58 (USACE, 1988-a). Figure 1 shows the location map of the basin and proposed dam site. The project also includes two seventeen-mile long flood control channels downstream from the damsite. This report summarizes the findings from two elements of the Phase I Sediment Engineering Investigation (SEI) addressing concerns raised by higher authority regarding the estimated sediment yield at the reservoir site presented in the draft Project Feasibility Report (USACE, 1988-b). The two elements of the Phase I SEI are: (a) Geomorphic Analyses - conducted by Water Engineering & Technology, Inc. (WET), Fort Collins, CO, under a work order from CESP-K-ED-D, and (b) Sedimentation Analyses - conducted concurrently with the Geomorphic Investigation by the Hydrologic Engineering Center (HEC) in Davis, California. HEC's sedimentation analysis is intended to expand on previous work done by the Corps (USACE, 1988-b) to better estimate the average annual sediment yield at the proposed damsite and to also estimate single event sediment volumes for various probability storms. It does not address sediment issues associated with the flood control channels downstream from the damsite.

Therefore, the purpose of this Phase I SEI is to evaluate the geomorphic characteristics of the Caliente Creek drainage basin and to determine the potential sediment yield from the watershed and channels upstream from the proposed damsite.

## **2. Authorization and Study Participants**

Authorization for this investigation comes from House Document No. 367, 81st Congress and Intra-Army Order No. CESP-K-ED-D 89-68, dated 20 September, 1989. Mr. Ed Sing is the CESP-K coordinator for the study, Mr. James Nightingale is the Project Engineer and Ms. Lauren Renning is the Individual Project Manager for the Caliente Creek Project. Dr. Michael Harvey was the project geomorphologist and geologist conducting the geomorphic analyses by Water Engineering & Technology and Dr. Robert MacArthur was the hydraulic engineer who conducted the sediment investigation and wrote this report for the Hydrologic Engineering Center.



**Figure 1**  
**Location Map for Caliente Creek Basin**

### 3. Approach

The Hydrologic Engineering Center reviewed available scientific and engineering literature pertaining to methods for estimating sediment yield and evaluating sediment transport processes on alluvial fans. HEC conducted a three-day field reconnaissance and sediment data collection investigation, interviewed persons familiar with the Caliente Creek Project and watershed, and conducted a series of sediment engineering analyses to determine the possible sedimentation characteristics of the drainage basin at the damsite. Morphometric data for the alluvial fan in the vicinity of the proposed reservoir site were



obtained from 2-foot contour mapping provided by the Sacramento District (CESPK). The field reconnaissance and sediment data collection investigation was conducted during October 3 through October 5, 1989. Messrs. E.F. Sing and T. Marx (CESPK-ED-D), Dr. R.C. MacArthur (CEWRC-HEC-T) and Dr. M.D. Harvey (WET) conducted the field investigations and sediment sampling. They inspected the entire Caliente Creek watershed, including Tehachapi Creek and its tributaries Blackburn Canyon and Antelope Creek, Caliente Creek and its tributary Indian Creek, and the upper reaches of Walker Basin Creek. A detailed inspection of Caliente Creek between Bena and the proposed reservoir site was conducted. Portions of the Caliente Creek fan downstream from the proposed damsite were inspected on Panama Rd. and at Tejon Rd. Sixteen sediment samples (bed material and a few bank material samples) and two Wolman Counts (Wolman, 1954) were collected at representative locations throughout the drainage basin from the 1983 flood deposits and in active alluvial channel sections. During the field reconnaissance information was obtained from Mr. Scott Frazer, District Conservationist for the USDA Soil Conservation Service in Tehachapi and from the Kern County Water Agency (Messrs. D.K. Sorenson and R. Iger) in Bakersfield, CA. Mr. Iger accompanied the field inspection team during their visit to the proposed reservoir site and to the lower reaches of Caliente Creek. In early November 1989, Mr. Tom Marx (from CESPK) spent one day examining the Kern County Water Agency's (KCWA) files and data records pertaining to the Caliente Creek drainage basin and project area. Materials obtained during his visit to KCWA were used extensively throughout this study. Personnel from the KCWA provided additional help and cooperation throughout the conduct of both studies (the geomorphic and sediment investigations). CESPK and HEC are very grateful for their courteous and timely assistance.

Additional data and information used by the study team to conduct the investigation are listed in the References section of this report.

Harvey (1989) reports the detailed Regional Geology (including Stratigraphy, Basement Complexity, Sedimentary Formations, Structure, and Faulting). He also discusses the complex Watershed and Channel Morphology, Sedimentology and Geomorphology of the Caliente Creek Basin and Alluvial Fan Complex. Appendix A presents the Executive Summary from Harvey's (1989) report, entitled: "Caliente Creek, California Project - Geomorphic Analysis." Detailed field observations are also reported by Harvey (1989) along with photographs of the area and field mapping that was prepared during the field inspection. Harvey's (1989) primary conclusions include: (1) the potential for sediment delivery to the reservoir site is controlled by the transport capacity of the alluvial channel system (valley width and channel slope), (2) episodic debris flows, mass failure of colluvial slope deposits and incision into old fan deposits accounts for major portions of the active bed material transported to the lower basin during flood events, (3) basin geomorphology supports the possibility that peak discharges may be underestimated, (4) floodflows may bypass the detention basin under its present configuration if floodflows become concentrated on the eastern side of the lower fan, and (5) floodflows can (and have recently) undercut the Sand Hills along the western margin of the fan, resulting in the delivery of significant volumes of sediment directly to the proposed reservoir site.

#### **4. Estimation of Basin Sediment Delivery and Yield to the Proposed Reservoir**

In order to determine the amount of sediment that may possibly enter the proposed reservoir during its design life (100 years), both the average annual sediment yield and single event sediment yields are estimated using a variety of sediment engineering procedures as reported in EM 1110-2-4000, "Sediment Investigations of Rivers and Reservoirs," (USACE, 1988) and recommended by others.

##### **4.1 Average Annual Sediment Yield**

The average annual sediment yield at the proposed reservoir site was estimated using results from eight different sources of data and/or methods for estimating sediment yield. The following procedures were used: (1) Previous reports and publications were thoroughly reviewed for available data, (2) USDA (1977) published reservoir sedimentation rates were examined, (3) recent USACE reservoir sedimentation survey data were analyzed, (4) sediment yield maps for the Western United States (USDA, SCS, 1975) were examined, (5) the average annual sediment yield was estimated from computations of the total event sediment volumes for single events ranging from the 2-year event up to the PMF based on channel transport capacity rather than watershed sediment production and delivery, (6) a flow duration and sediment load curve integration method (see EM 1110-2-4000, USACE, 1989) was used to estimate the average annual sediment production and yield to the reservoir site, (7) the Pacific Southwest Inter-Agency Committee (PSIAC) method was used to estimate basin-wide sediment yield from the entire watershed, and (8) the Dendy and Bolton (1976) Regional Analysis Method for sediment yield was applied. Results from these analyses are discussed next. Detailed procedures for conducting such investigations are presented in the references cited in the text, in Engineering Manual 1110-2-4000 (USACE, 1989) and listed in the References Section of this report. **Table 1** summarizes the results.

The Caliente Creek, CA project Hydrology Office Report (USACE, 1980) and the Feasibility Study Documentation Report (USACE, 1988) present an estimated average annual sediment deposition rate at the proposed Sivert Dam site of 0.38 AF/sq mi/yr (approximately 180 acre-feet per year). This estimate was based on measured average annual reservoir sedimentation rates reported for the Kern River Basin and on SCS (Stearns, 1978) sediment yield estimates prepared for two proposed flood detention basins located in the Tehachapi Mountains above Tehachapi. Since 1978, when Stearns first estimated an average annual sediment yield of approximately 0.65 AF/sq mi/yr for Blackburn Canyon and Antelope Creek (tributaries to the Tehachapi Creek), the SCS has revised (increased) the annual sediment production rate estimates to 1.5 AF/sq mi/yr and 2.2 AF/sq mi/yr for the Antelope and Blackburn drainages, respectively (USDA, SCS, 1980). The revised values are listed in **Table 1**. These drainage basins are relatively small (less than 10 sq mi each) and are very steep and will, therefore, have a high sediment delivery ratio. Larger drainage basins deliver smaller amounts of the total sediment they produce to the lower reaches of the watershed because of interception (capture) and deposition that occurs along the way. Blackburn and Antelope basins are also comprised of weathered granitic parent materials and, therefore, the sediment yields of the magnitude reported for those basins may not be representative of the sediment production and delivery characteristics at the reservoir site.

**TABLE 1**

**Sediment Surveys for Reservoirs in the Vicinity  
of Caliente Creek, California, and Estimated  
Average Annual Sediment Yields Based on Various  
Computational Methods**

Data Source	References <sup>1</sup>	Drainage Basin, Reservoir or Computational Method Used	Drainage Area (sq mi)	Average Annual Yield (AF/sq mi/yr)
SCS	34	Blackburn	7.1	2.20
SCS	34	Antelope Canyon	4.4	1.50
CESPK <sup>2</sup>		Isabella	2,074	0.37
CESPK	33	Pine Flat	1,542	0.20
CESPK	33	Success	393	0.76
CESPK	33	Terminus	560	0.75
SCS	32	SCS Yield Map of Wester US (HEC) <sup>3</sup>	470	0.47
Computed	29	Integration of the Event Volume vs. Frequency Curve (HEC)	470	0.55
Computed	29	Flow Duration Method (HEC)	470	0.90
Computed	29	Dendy & Bolton Method (HEC)	470	0.71
Computed	14	PSIAC Method (HEC)	470	0.75
Computed	17	Kern County Water Agency Study (SLA)	470	0.97

<sup>1</sup> The numbers listed correspond to the references cited in the reference section starting on page 25.

<sup>2</sup> Personal communication with CESPK-ED-H/Herb Hereth (11/21/89).

<sup>3</sup> Letters in parenthesis indicate whether the Hydrologic Engineering Center (HEC) or Simons, Li & Associates (SLA) performed the calculations.

Because of their close proximity to Caliente Creek and similar hydrologic characteristics and geology, the SCS reported values for the Blackburn and Antelope basins do provide an approximate upper bound for the estimated sediment yield near the proposed reservoir site.

**Table 1** presents measured reservoir survey data reported by the USDA (1977) from catchments located relatively near to the study area. It also lists sediment yields estimated from SCS Yield Maps and other values computed using various sediment yield methods. **Figure 2** presents the location of the six different drainage areas that were used to compare basin wide sediment yields. Lake Isabella, Kern Co. and Pine Flat Dam, Kings Co. have different geologic characteristics than those found in the Caliente Creek Basin. Their



effective drainage areas are much larger (by 77 %) than the Caliente Creek Basin and the maximum watershed elevations are also higher. The measured yields at Lake Isabella and Pine Flat are approximately 0.37 and 0.20 AF/sq mi/yr, respectively.

Success Lake, in Tulare Co. and Kaweah Lake (Terminus Dam), in Tulare Co. are more representative of the kinds of geology and basin watershed conditions found in the Caliente Basin. The Sacramento District Corps of Engineers is presently conducting survey studies to re-evaluate several of their reservoirs in the vicinity of Caliente Creek. At the time of this reporting, most of the new data were not available. However, the sediment yield for Lake Isabella has been revised and is reported in **Table 1** along with the revised yields for Blackburn and Antelope reported by the SCS (1980). Therefore, based on measured sediment accumulation rates recorded in the Tulare, Kings, and Kern County reservoirs (as of 11/20/89), having effective drainage basin areas larger than 390 square miles, the approximate range of observed sediment yields is from 0.2 AF/sq mi/yr to 0.76 AF/sq mi/yr., or approximately 94 to 357 acre-feet per year based on the Caliente Creek Basin drainage area of 470 sq mi.

Sediment yield rates for the Western United States are reported by the USDA, SCS (1975). From the mapping of yield rates, it appears that the upper Caliente watershed area has sediment yield rates from 0.2 to 0.5 AF/sq mi/yr, with pockets as high as 0.5 to 1.0 AF/sq mi/yr. In the lower portions of the basin, on the valley floor and on portions of the broad alluvial fan, the estimated yields are reported to be in the range of 0.1 to 0.2 AF/sq mi/yr. Using area weighting methods to sum the yields from contributing subbasins, the approximate annual yield appears to range from 0.2 to about 0.75 AF/sq mi/yr, with an average of about 0.47 AF/sq mi/yr for the entire watershed (approximately 221 acre feet per year at the dam site).

Another approach used to check these annual yield estimates was based on the transport capacity of the channels in the supply reach. The supply reach is a 4-mile section of the channel considered to be representative of the channel hydraulic conditions and sediment transport characteristics upstream from the dam site. Single event total sediment volumes were computed for each of the 20%, 10%, 5%, 2%, 1%, SPF, and PMF events. The total sediment production for each event was based on the sediment transport capacity of the alluvial channel (supply reach) upstream from the reservoir and the flow hydrographs used for each of the flood events evaluated. The flow hydrographs for the Sivert Dam site were prepared by ratioing the coordinates of the 5-day SPF general rain hydrograph (Chart 63, USACE, 1980) developed for the Pampa dam site (see **Tables 2 and 3** in this report for the developed hydrographs). A total sediment load versus percent exceedance curve was developed from these data and the area under the total load frequency curve was computed to give an estimate for the expected average annual sediment delivery to the reservoir based on channel transport capacity upstream from the reservoir. Two different transport relationships were used to develop the total load curves (the New Laursen and Copeland Laursen methods). Vanoni (1975), Williams and Julien (1989) and Nakato (1990) discuss the differences between many of the often-used transport functions. The resulting average annual sediment delivery ranged from 0.1 AF/sq mi/yr to 1.0 AF/sq mi/yr due to the difference in transport capacity computed with the transport functions. Using these results as a representative range in expected yields based on channel capacity, an average of the two yields seems reasonable. Therefore, based on the channel transport capacity above the

reservoir site and the estimated total sediment production from a range of single events, an approximate sediment yield at the reservoir is 0.55 AF/sq mi/yr. The average yield (0.55 AF/sq mi/yr) produces approximately 260 acre feet of sediment each year, while the higher estimated yield (1.0 AF/sq mi/yr) produces 470 acre feet of sediment each year.

This method does not account for the additional contribution of sediment from dry ravel erosion, wind-blown sand transport into the channel or reservoir, channel bank caving, local scour, or toe failure that may occur along the Sand Hills. Therefore, the sediment yield to the reservoir may be as high as the higher of the two transport functions predicts, especially during periods of exceptionally wet years.

The "flow duration sediment discharge rating curve method," (USACE, 1989) is a simple method where the flow duration curve is integrated with the sediment discharge rating curve at the outflow point (at the Sivert Damsite) of the basin. It is very similar to the method just described, however, the average annual sediment yield is based on the channel transport capacity and flow duration relationships rather than the total event volume frequency. The method is the most common method used in the Corps of Engineers for estimating basin sediment yield (USACE, 1989). A mean daily flow, flow duration curve was developed for Caliente Creek at the Sivert damsite by the Hydrology Section of the Sacramento District Corps of Engineers. That relationship along with the total sediment load curve for the channel reach located upstream from the damsite are used to compute the average annual sediment yield to the reservoir. (Methods used to develop the load curve are discussed in the following section.) HEC utilized an unpublished utility computer code called SEDYLD89 (recently developed by the Waterways Experiment Station) to integrate the load relationship and the flow duration curves to compute the average annual sediment yield. The resulting annual sediment yield is approximately 438 AF/year, or 0.9 AF/sq mi/yr.

Further examination of the USDA, SCS (1975) "Sediment Yield Rates for the Western United States" shows areas in the vicinity of the proposed dam site with estimated yields from 0.5 to 1.0 AF/sq mi/yr. These areas may correspond to the broad floodplain channels (4000 to 6500 feet wide) immediately upstream from the proposed reservoir site. If that is the case, then the higher yield values estimated with the channel transport capacity method (1.0 AF/sq mi/yr) and the flow duration method (0.9 AF/sq mi/yr) are supported by SCS yield mapping estimates.

The Dendy and Bolton (1976) method is a widely applicable regional method recommended by Engineering Manual 1110-2-4000 (USACE, 1989). Dendy and Bolton's regression relationships for sediment yield are based on measured sedimentation rates in over 800 reservoirs throughout the continental United States. The relationships associate basin drainage area and mean annual runoff to average annual sediment yield. The Dendy and Bolton (1976) method produces an average annual sediment yield of approximately 0.71 AF/sq mi/yr (334 acre feet /yr) for the Caliente Basin at the Sivert damsite.

The Pacific Southwest Inter-Agency Committee (PSIAC) sediment yield method (PSIAC, 1968) was also used. The PSIAC method was developed specifically for use in the Pacific Southwest and has been considered by many to be one of the most reliable total sediment yield methods for use in the western states. Application of PSIAC procedures to

the Caliente Creek watershed produces an estimated average annual sediment yield of 0.75 AF/sq mi/yr at the dam site. This value is right in line with the range of values predicted from the channel capacity approach and the measured reservoir accumulation results from Tulare County.

Summing all of the sediment yields reported above and dividing by the number of entries gives an arithmetic average of 0.76 AF/sq mi/yr. Examining these results in light of the geomorphic characteristics of Caliente Creek Basin (see Harvey, 1989), the most reliable value for the annual basin averaged sediment yield at the proposed reservoir site is 0.76 AF/sq mi/yr, or approximately 357 acre feet of sediment per year.

During the fall of 1989, the Kern County Water Agency (KCWA) hired their own private consultant to conduct an independent assessment of the proposed Caliente Creek Project. The consultant was tasked with estimating the average annual sediment yield and the 1% chances (100-year) flood sediment yield at the proposed damsite. KCWA hired Simons, Li and Associates, Inc. (SLA) from Newport Beach, California, to perform the sediment investigation. They met with KCWA staff to discuss past flooding events, data needs for their analyses and the overall features of the project. SLA (1989) estimated that the average annual sediment yield is approximately 0.51 AF/sq mi/yr (241 AF/yr). They also reported that the annual sediment yield can be as high as 1.42 AF/sq mi/yr or 672 acre feet per year. The arithmetic average of these two yield estimates (**0.97 AF/sq mi/yr**) developed by SLA for the Kern County Water Agency is reported in **Table 1**.

If the KCWA average annual sediment yield (0.97 AF/sq mi/yr) is averaged with the eleven other (HEC) yield values presented in **Table 1**, the new arithmetic average yield becomes 0.84 AF/sq mi/yr. If the maximum annual yield reported by SLA is averaged with the previous eleven values the average yield is 0.88 AF/sq mi/yr. **Figure 3** shows all thirteen yield values and the drainage basin area associated with each yield. A best fit line through these data points gives an average annual sediment yield of **0.75 AF/sq mi/yr**.

It is important to note that arid and semi-arid basins, such as Caliente Creek, are very episodic in nature. During dry years (perhaps even normal years) the sediment production and delivery (and, therefore, annual yield) is small. During large runoff events the sediment production and delivery can produce tremendous loads of sediment in the channels. The annual yield during an excessively wet year can be quite high. Therefore, the presentation of a single average annual yield value may be misleading. For planning purposes, the consideration of the range of possible annual yields is more meaningful.

## **4.2 Single Event Analyses**

In addition to the average annual sediment yield developed above, it is important to estimate the sediment production and delivery from possible single events ranging from small 20% chance (5-year) flows to the 1% chance design event (100 year flood) and the SPF and PMF. One or more single events during the design life (100 years) of the project can significantly affect the operation and maintenance of the reservoir much more than average annual events.

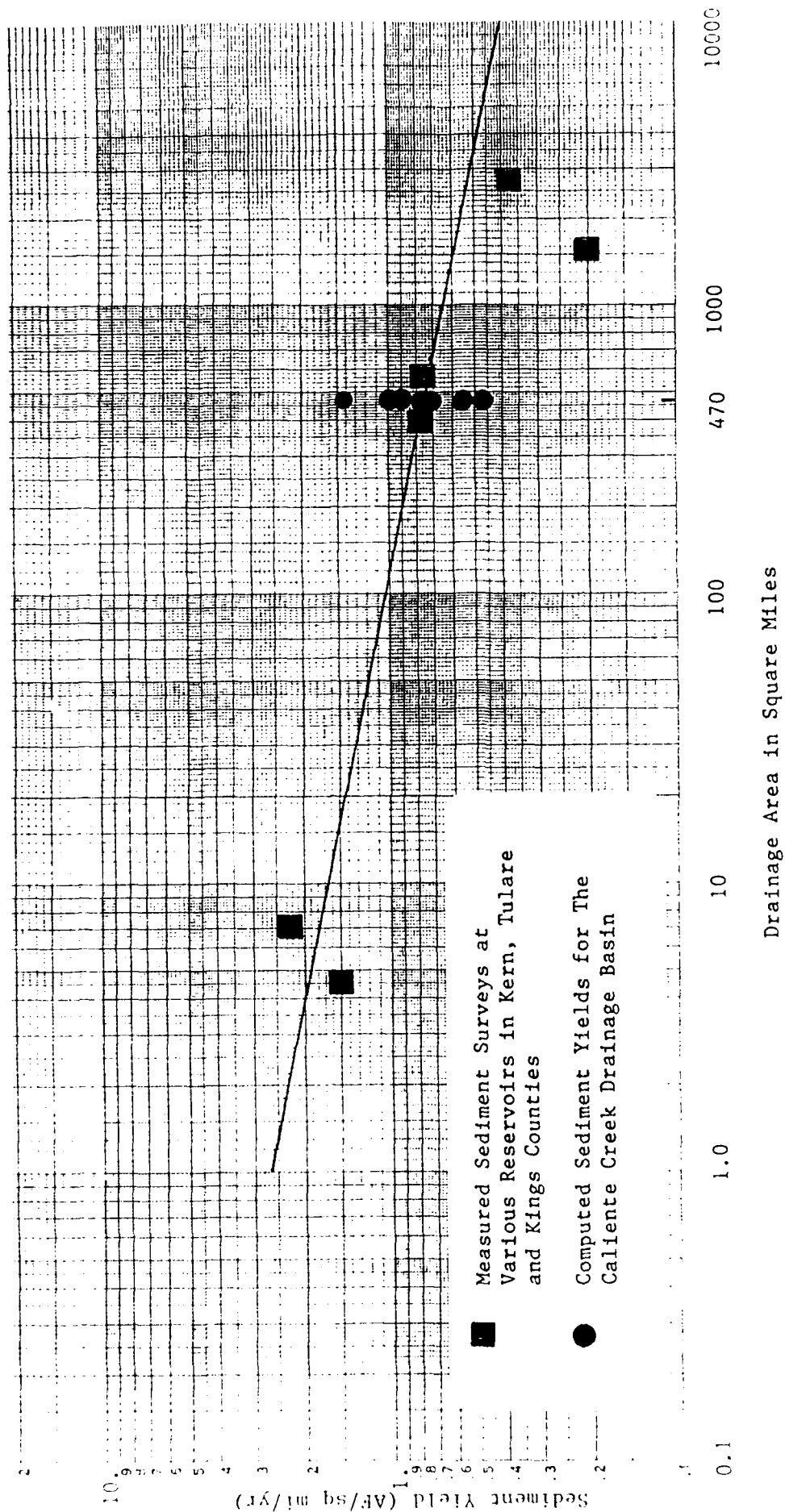




Figure 4 shows a sketch of the study reach that was used to estimate the single event sediment delivery to the reservoir site. The subreach areas shown in the sketch are not to scale. These same subreaches were used to develop the transport capacity-based sediment yields discussed previously in Section 4.1. There are four different subreaches based on distinct hydraulic and geomorphic characteristics (see Harvey, 1989): (1) the upstream sediment supply reach, (2) the reach located just upstream from the highway 58 crossing, (3) the reach just downstream from Highway 58, and (4) the reach located in the reservoir pool area. Four different subreaches are analyzed so that the transport capacity computed for each subreach can be compared to the others with different hydraulic and geomorphic characteristics. These subreaches are evaluated according to their sediment transporting capacity based on the use of seven different transport functions, including: (1) Toffaleti, (2) Yang, (3) Acker-White, (4) Colby, (5) Meyer-Peter Muller, (6) New Laursen, and (7) Copeland Laursen. Vanoni (1975), Williams and Julien (1989) and Nakato (1990) discuss the difference between many of the most widely used sediment transport functions. An undocumented (research version) computer program developed at the Corps' Waterways Experiment Station was used to develop the sediment load curves with each of these methods using a channel-averaged sediment grain size and average channel hydraulic conditions for a given discharge at each of the three channel subreaches, 1 through 3. Subreach 4 (the reach located in the reservoir pool) was not evaluated because the transport capacity in the pool will be very close to zero. Sediment samples collected during the October, 1989 field reconnaissance study were analyzed in the laboratory to develop the grain size data necessary to perform the transport computations. Appendix B presents the detailed results from the laboratory investigations. Data from appendix B are used to develop the sediment grain size distribution curves most representative of the study subreaches identified in Figure 4. Figure 5 presents the reach averaged sediment grain size curve used for the sediment transport calculations. The  $D_{50}$ ,  $D_{84}$ , and  $D_{16}$  are approximately 0.75 mm, 2.4 mm, and 0.34 mm, respectively.

Appendix C presents the seven synthesized single event flood hydrographs used for the 20%, 10%, 5%, 2%, 1%, SPF, and PMF flood events. As discussed in Section 4.1, these hydrographs were developed by ratioing the coordinates of the 5-day general rain SPF hydrograph developed for the Pampa damsite to translate it to the Sivert damsite. Sediment load relationship curves were developed for the full range of expected flows for each of the three active transport subreaches (subreaches 1, 2, and 3). Families of load curves (sediment load in tons/day versus water discharge in cfs) were developed using the seven different transport functions listed above. These curves are provided in Appendix D. Because the Caliente Wash in the area of the proposed reservoir is so wide (on the order of 3,000 to 6,000 feet wide) the load curves were developed for two ranges of peak flows: (1) low flows including the 20%, 10%, 5%, and 2% chance flows, and (2) high flows including the 1% (100 year), SPF, and PMF. The low and high flow load curves were then combined to develop one continuous load curve for the full range of possible flows. Using the sediment load curves for each reach and the flow hydrograph for each event, the sediment load hydrographs for each event were computed. Summing the area under the sediment hydrographs gives the total bed material load in tons of sediment per event. These values are then compared to estimate the potential amount of sediment that can be delivered to the Sivert Reservoir for each magnitude of event.



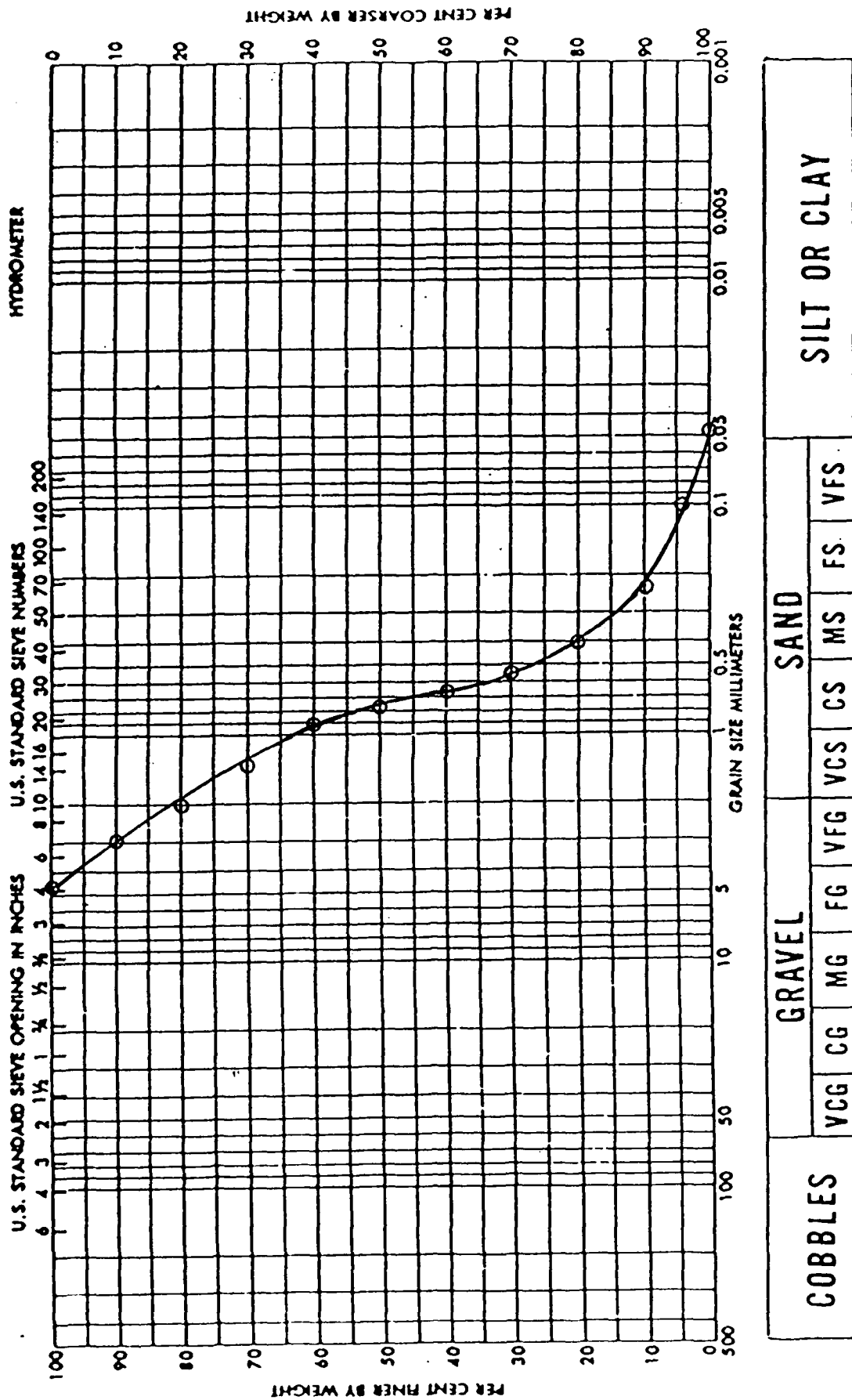


Figure 5  
Reach-Averaged Bed Material Grain Size  
Distribution Curve Caliente Creek, CA

The following assumptions are made for all of the single event analyses: (1) the eastern bridge opening under Highway 58 is closed, (2) Highway 58 can survive overtopping during high flows (the SPF and PMF events), (3) steady gradually varied flow hydraulic computations (HEC-2) are valid for estimating the channel hydraulic conditions for the full range of flows, (4) hyperconcentrated sediment loads will not affect the hydraulic computations, (5) mobile boundary effects will not affect the hydraulic computations, (6) the New Laursen and Copeland Laursen transport functions provide a good representation of the range of channel transport characteristics for all flows considered.

The Copeland Laursen and New Laursen methods are considered to be the most representative of the sediment transport characteristics found in the Caliente Creek Wash. The New Laursen method provides similar results as the Yang and Toffaleti methods. Colby and Meyer-Peter Muller methods are considered to underestimate the transport capacity. The Acker-White method over estimates the transport and gives unreasonably high concentrations of sediment per unit discharge. Therefore, the New Laursen and Copeland Laursen load curves are used for the remaining analyses to develop a range of possible sediment production rates based on the transport capacity of the Caliente Creek channel upstream from the reservoir site. **Tables 2 and 3** summarize the results from combining the water discharge hydrographs with the two different sediment load curves to compute total bed material load transported during each of the seven different events for each of the three active transport subreaches. The **total bed material load** transported during each event is listed at the bottom of the columns below each event category (eg, 5 year, 10 year, ..., 100 year, SPF, and PMF) in dry tons/event, cubic yards/event and acre feet/event. The **total sediment load** is listed in the bottom row of numbers and is based on the assumption that the **wash load** will contribute another 15 percent to the bed material load computed above. This is a conservative estimate for the wash load. Greater percentages of fines may be produced from the watershed during large runoff events.

Sediment transport rates computed with the Copeland Laursen method are approximately one order of magnitude larger than those computed by the New Laursen method. Estimates of the sediment concentrations for various flows as computed by the two different transport methods indicate the Copeland Laursen method yields larger concentrations of sediment for the same magnitude of water flow. As previously mentioned, the curves in Appendix D show that the results from the New Laursen method are similar to those computed with Yang and Toffaleti and fall approximately midway between the large spread found in the seven different curves. It is the author's opinion that the New Laursen method probably under estimates the actual sediment transport characteristics found in the broad Caliente Creek Wash upstream from the damsite. The Copeland Laursen method provides a more likely value of the bed material transport per unit discharge in Caliente Creek because it uses the hydraulic radius due to grain roughness to compute bed shear for different flow intensities and flow depths. The Copeland Laursen method accounts for the effects of grain size and bed roughness more explicitly than the other transport functions and, therefore, better accounts for the transport of bed materials found along the Caliente fan. These effects are important during large flow events. The Copeland Laursen method has been successfully used in the design of several Corps of Engineers flood control channels in California.

NEW LAURSEN  
BED MATERIAL LOAD BELOW HIGHWAY 58

RMF 7.740

RSF 2.460

R100 1.196

R50 0.683

R20 0.288

R10 0.130

R5 0.046

DURATION (days)	HOURS	QBASE	Q5	R10	R20	R50	Q100	Q5pf	Qpmf	Q55	Q510	Q520	Q550 (tons/day)	Q5100	Q5spf	Q5pmf
0	0	50	2	7	14	34	60	123	387	1.22E+02	4.27E+02	8.54E+02	2.07E+03	3.66E+03	7.50E+03	2.36E+04
12	12	100	5	13	29	66	120	246	774	3.05E+02	7.93E+02	1.77E+03	4.15E+03	7.32E+03	1.50E+04	4.72E+04
18	18	4270	196	555	1230	2916	5107	10304	33050	1.20E+04	3.38E+04	7.50E+04	1.82E+05	3.34E+05	7.54E+05	1.56E+06
24	24	1350	62	176	389	922	1615	3321	10449	3.78E+03	1.07E+04	2.37E+04	5.62E+04	9.92E+04	2.01E+05	7.50E+05
36	36	400	18	52	115	273	478	984	3096	1.10E+03	3.17E+03	7.01E+03	1.66E+04	2.91E+04	6.00E+04	1.93E+05
44	44	670	31	87	193	458	801	1548	5186	1.89E+03	5.31E+03	1.18E+04	2.78E+04	4.88E+04	1.01E+05	3.40E+05
48	48	3200	147	416	922	2186	3827	7872	24768	8.96E+03	2.54E+04	5.62E+04	1.35E+05	2.44E+05	5.40E+05	1.93E+06
52	52	2400	110	312	691	1639	2870	5904	18576	6.71E+03	1.90E+04	4.21E+04	1.01E+05	1.79E+05	3.81E+05	1.26E+06
60	60	6200	285	806	1786	4235	7415	15252	47988	1.74E+04	4.91E+04	1.10E+05	2.73E+05	5.02E+05	1.14E+06	2.42E+06
64	64	9350	430	1216	2693	6386	11183	23001	72369	2.62E+04	7.41E+04	1.68E+05	4.25E+05	8.09E+05	1.31E+06	3.89E+06
66	66	15000	690	1950	4320	10245	17940	36900	116100	4.21E+04	1.20E+05	2.78E+05	7.33E+05	1.23E+06	1.78E+06	7.01E+06
68	68	23000	1058	2990	6624	15709	27508	56580	178020	6.45E+04	1.86E+05	4.42E+05	1.18E+06	1.36E+06	2.91E+06	1.24E+07
72	72	16000	736	2080	4608	10928	19136	39360	123840	4.49E+04	1.29E+05	2.99E+05	7.89E+05	1.26E+06	1.82E+06	7.54E+06
76	76	8000	368	1040	2304	5464	9568	18680	61920	2.24E+04	6.34E+04	1.43E+05	3.60E+05	6.78E+05	1.27E+06	3.27E+06
78	78	4800	221	624	1382	3278	5741	11808	37152	1.35E+04	3.81E+04	8.45E+04	2.05E+05	3.79E+05	8.60E+05	1.80E+06
80	80	2950	136	384	850	2015	3528	7257	22833	8.29E+03	2.34E+04	5.18E+04	1.25E+05	2.23E+05	4.89E+05	1.31E+06
84	84	1350	62	176	389	922	1615	3321	10449	3.78E+03	1.07E+04	2.37E+04	5.62E+04	9.92E+04	2.01E+05	7.50E+05
88	88	550	25	72	158	376	658	1353	4257	1.52E+03	4.39E+03	9.63E+03	2.29E+04	4.01E+04	8.26E+04	2.74E+05
96	96	500	23	65	144	342	598	1230	3870	1.40E+03	3.96E+03	8.78E+03	2.09E+04	3.65E+04	7.50E+04	2.47E+05
104	104	275	13	36	79	188	329	677	2129	7.93E+02	2.20E+03	4.82E+03	1.15E+04	2.01E+04	4.13E+04	1.32E+05
112	112	100	5	13	29	68	120	246	774	3.05E+02	7.93E+02	1.77E+03	4.15E+03	7.32E+03	1.50E+04	4.72E+04
120	120	5	0	1	1	3	6	12	39	0.00E+00	6.10E+01	6.10E+01	1.83E+02	3.66E+02	7.32E+02	2.38E+03

SINGLE EVENT HYDROGRAPH COORDINATES  
(hours vs cfs)

TABLE 2

Summary of Single Event Sediment Transport Capacity Analyses  
Based on the New Laursen Bed Material Transport Capacity  
Procedures

107	305	656	1555	2744	5625	17699
1532	4329	9596	23228	42725	96128	201111
1967	5572	12340	29737	54212	120243	288904
1220	3476	7683	18217	32092	66981	235656
498	1413	3130	7429	12988	28885	88860
905	2556	5666	13611	24385	53402	139145
1306	3698	8196	19679	35211	77539	215669
4014	11362	25365	62238	113504	255325	612724
3633	10275	23133	58150	109302	204192	533891
2846	8108	18594	48251	85850	128821	458247
4441	12784	30029	79631	108844	195537	806677
9116	26255	61758	163901	218836	402826	1657905
5610	16009	36834	93696	161878	266206	900902
1496	4228	9472	23527	44048	88807	210992
907	2561	5678	13727	25083	56237	129342
1006	2846	6296	15066	26817	58109	171410
442	1260	2780	6596	11612	24211	8531E
488	1392	3069	7297	12765	26269	86845
366	1026	2266	5386	9421	19381	63103
183	498	1088	2602	4563	9380	29832
51	142	305	722	1281	2622	8262

-----  
BED MATERIAL LOAD (in tons) TRANSPORTED DURING 5 DAY EVENT  
4.21E+04 1.20E+05 2.74E+05 6.86E+05 1.14E+06 2.18E+06 6.94E+06

BED MATERIAL LOAD (in cubic yards) TRANSPORTED DURING 5 DAY EVENT  
3.29E+04 9.37E+04 2.14E+05 5.43E+05 8.88E+05 1.70E+06 5.42E+06

BED MATERIAL LOAD (in acre-feet) TRANSPORTED DURING 5 DAY EVENT  
2.11E+01 6.00E+01 1.37E+02 3.48E+02 5.69E+02 1.09E+03 3.47E+03

TOTAL LOAD<sup>1</sup>(AF)/EVENT  
24.3 69 158 400 654 1253 3990

<sup>1</sup>TOTAL LOAD = BED MATERIAL LOAD + 15% for WASH LOAD (in acre-feet (AF))

TABLE 2  
(continued)

NEW LAURSEN BED MATERIAL LOAD JUST ABOVE HIGHWAY 58										NEW LAURSEN BED MATERIAL LOAD FROM UPSTREAM SUPPLY REACH									
QS5	QS10	QS20	QS50 (tons/day)	QS100	QSsptf	QSpmf	QS5	QS10	QS20	QS50 (tons/day)	QS100	QSsptf	QSpmf						
1.00E+02	3.50E+02	7.00E+02	1.70E+03	3.00E+03	6.15E+03	1.94E+04	1.18E+02	4.14E+02	8.27E+02	2.01E+03	3.54E+03	7.27E+03	2.29E+04						
2.50E+02	6.50E+02	1.45E+03	3.40E+03	6.00E+03	1.23E+04	3.87E+04	2.95E+02	7.68E+02	1.71E+03	4.02E+03	7.09E+03	1.45E+04	4.57E+04						
9.80E+03	2.78E+04	6.15E+04	1.49E+05	2.68E+05	5.85E+05	1.32E+06	1.16E+04	3.28E+04	7.27E+04	1.83E+05	3.20E+05	6.12E+05	2.18E+06						
3.10E+03	8.80E+03	1.95E+04	4.61E+04	8.10E+04	1.70E+05	5.81E+05	3.66E+03	1.04E+04	2.30E+04	5.45E+04	9.77E+04	2.10E+05	6.10E+05						
9.00E+02	2.60E+03	5.75E+03	1.37E+04	2.39E+04	4.92E+04	1.58E+05	1.06E+03	3.07E+03	6.79E+03	1.61E+04	2.82E+04	5.81E+04	1.95E+05						
1.55E+03	4.35E+03	9.65E+03	2.29E+04	4.01E+04	8.27E+04	2.72E+05	1.83E+03	5.14E+03	1.14E+04	2.71E+04	4.73E+04	9.89E+04	3.24E+05						
7.35E+03	2.08E+04	4.61E+04	1.11E+05	1.97E+05	4.26E+05	1.21E+06	6.88E+03	2.46E+04	5.45E+04	1.35E+05	2.44E+05	4.78E+05	1.49E+06						
5.50E+03	1.56E+04	3.46E+04	8.22E+04	1.47E+05	3.11E+05	9.95E+05	6.50E+03	1.84E+04	4.08E+04	9.93E+04	1.80E+05	3.65E+05	1.00E+06						
1.43E+04	4.03E+04	8.99E+04	2.20E+05	3.98E+05	8.71E+05	1.36E+06	1.68E+04	4.76E+04	1.09E+05	2.70E+05	4.52E+05	8.41E+05	3.32E+06						
2.15E+04	6.08E+04	1.37E+05	3.39E+05	6.26E+05	1.15E+06	1.44E+06	2.54E+04	7.18E+04	1.69E+05	3.93E+05	6.45E+05	1.33E+06	5.33E+06						
3.45E+04	9.85E+04	2.25E+05	5.69E+05	9.73E+05	1.33E+06	1.91E+06	4.08E+04	1.20E+05	2.75E+05	6.00E+05	9.71E+05	2.47E+06	9.13E+06						
5.29E+04	1.53E+05	3.51E+05	8.97E+05	1.30E+06	1.39E+06	2.57E+06	6.25E+04	1.88E+05	4.06E+05	8.63E+05	1.73E+06	3.98E+06	1.45E+07						
3.68E+04	1.03E+05	2.40E+05	6.10E+05	1.01E+06	1.34E+06	1.99E+06	4.35E+04	1.28E+05	2.91E+05	6.33E+05	1.03E+06	2.66E+06	9.80E+06						
1.84E+04	5.20E+04	1.17E+05	2.87E+05	5.28E+05	1.03E+06	1.41E+06	2.17E+04	6.14E+04	1.43E+05	3.40E+05	5.67E+05	1.05E+06	4.42E+06						
1.11E+04	3.12E+04	6.91E+04	1.68E+05	3.03E+05	6.83E+05	1.33E+06	1.31E+04	3.69E+04	8.23E+04	2.07E+05	3.56E+05	6.75E+05	2.49E+06						
6.80E+03	1.92E+04	4.25E+04	1.02E+05	1.81E+05	3.89E+05	1.14E+06	8.03E+03	2.27E+04	5.02E+04	1.24E+05	2.24E+05	4.43E+05	1.32E+06						
3.10E+03	8.80E+03	1.95E+04	4.61E+04	8.10E+04	1.70E+05	5.81E+05	3.66E+03	1.04E+04	2.30E+04	5.45E+04	9.77E+04	2.10E+05	6.10E+05						
1.25E+03	3.60E+03	7.90E+03	1.88E+04	3.29E+04	6.77E+04	2.21E+05	1.48E+03	4.25E+03	9.33E+03	2.22E+04	3.89E+04	8.04E+04	2.71E+05						
1.15E+03	3.23E+03	7.20E+03	1.71E+04	2.99E+04	6.15E+04	2.00E+05	1.36E+03	3.84E+03	8.51E+03	2.02E+04	3.53E+04	7.27E+04	2.46E+05						
6.50E+02	1.80E+03	3.95E+03	9.40E+03	1.65E+04	3.39E+04	1.08E+05	7.68E+02	2.13E+03	4.67E+03	1.11E+04	1.94E+04	4.00E+04	1.32E+05						
2.50E+02	6.50E+02	1.45E+03	3.40E+03	6.00E+03	1.23E+04	3.87E+04	2.95E+02	7.68E+02	1.71E+03	4.02E+03	7.09E+03	1.45E+04	4.57E+04						
0.00E+00	5.00E+01	5.00E+01	1.50E+02	3.00E+02	6.00E+02	1.95E+03	0.00E+00	5.91E+01	5.91E+01	1.77E+02	3.54E+02	7.09E+02	2.30E+03						

1257	3551	7872	19041	34216	74611	169508	14518
1613	4571	10123	24380	43588	94333	237328	169508
1000	2851	6302	14943	28222	54824	184899	169508
408	1159	2568	6094	10663	21987	71732	169508
742	2097	4648	11142	19793	42390	123214	169508
1071	3035	6723	16086	28665	61455	183456	169508
3293	9320	20745	50347	90827	197032	393326	169508
2980	8428	18932	46483	83328	168071	233977	169508
2334	6637	15075	37788	66614	113157	139526	169508
3643	10469	23980	61083	94705	113477	186335	169508
7478	21504	49279	125597	192815	227488	379547	169508
4602	13107	29774	74789	128523	197513	283153	169508
1228	3468	7754	18965	34613	70660	141460	169508
744	2101	4652	11237	20149	43837	102951	169508
825	2334	5165	12332	21835	46593	143473	169508
363	1034	2280	5410	9491	19813	66861	169508
400	1142	2518	5986	10471	21533	70146	169508
300	842	1859	4418	7728	15898	51273	169508
150	408	900	2134	3743	7695	24423	169508
42	117	250	592	1050	2151	6778	169508

BED MATERIAL LOAD (in tons) TRANSPORTED DURING 5 DAY EVENT									
3.46E+04	9.84E+04	2.22E+05	5.50E+05	9.33E+05	1.59E+06	3.18E+06			

BED MATERIAL LOAD (in cubic yards) TRANSPORTED DURING 5 DAY EVENT									
2.70E+04	7.68E+04	1.73E+05	4.29E+05	7.28E+05	1.24E+06	2.48E+06			

BED MATERIAL LOAD (in acre-feet) TRANSPORTED DURING 5 DAY EVENT									
1.73E+01	4.92E+01	1.11E+02	2.75E+02	4.67E+02	7.95E+02	1.59E+03			

TOTAL LOAD(AF)/EVENT									
20	57	128	316	537	924	1829			

BED MATERIAL LOAD (in tons) TRANSPORTED DURING 5 DAY EVENT									
4.08E+04	1.18E+05	2.63E+05	6.11E+05	1.07E+06	2.32E+06	8.40E+06			

BED MATERIAL LOAD (in cubic yards) TRANSPORTED DURING 5 DAY EVENT									
3.18E+04	9.22E+04	2.07E+05	4.76E+05	8.32E+05	1.81E+06	6.55E+06			

BED MATERIAL LOAD (in acre-feet) TRANSPORTED DURING 5 DAY EVENT									
2.04E+01	5.91E+01	1.33E+02	3.05E+02	5.33E+02	1.16E+03	4.20E+03			

TOTAL LOAD(AF)/EVENT									
23.5	68	153	351	613	1334	4830			

COPELAND LAURSEN  
BED MATERIAL LOAD BELOW HIGHWAY 58

R5 0.046 R10 0.130 R20 0.288 R50 0.683 R100 1.196 RSF 2.460 RPF 7.740

DURATION (days)	HOURS	QBASE	Q5	Q10	Q20 (cfs)	Q50	Q100	QSPF	QPMF	Q55	Q510	Q520	Q530 (tons/day)	Q5100	Q5SPF	Q5PMF
0	0	50	2	7	14	34	60	123	387	1.23E+03	4.32E+03	8.64E+03	2.10E+04	3.70E+04	7.58E+04	2.39E+05
12	12	100	5	13	29	68	120	246	774	3.09E+03	8.03E+03	1.79E+04	4.20E+04	7.41E+04	1.52E+05	4.78E+05
0.5	18	4270	196	555	1230	2916	5107	10304	33050	1.21E+05	3.43E+05	7.59E+05	2.28E+06	4.00E+06	8.80E+06	9.05E+06
0.25	24	1350	62	176	389	922	1615	3321	10449	3.83E+04	1.09E+05	2.40E+05	5.69E+05	1.09E+06	2.63E+06	8.83E+06
0.5	36	400	18	52	115	273	478	984	3096	1.11E+04	3.21E+04	7.10E+04	1.69E+05	2.95E+05	6.08E+05	2.44E+06
0.33333	44	670	31	87	193	458	801	1648	5186	1.91E+04	5.37E+04	1.19E+05	2.83E+05	4.95E+05	1.12E+06	4.06E+06
0.16666	48	3200	147	416	922	2186	3827	7872	24768	8.08E+04	2.57E+05	5.69E+05	1.61E+06	3.02E+06	6.30E+06	1.05E+07
0.16666	52	2400	110	312	691	1639	2870	5904	18576	6.79E+04	1.93E+05	4.27E+05	1.11E+06	2.23E+06	4.61E+06	1.36E+07
0.33333	60	6200	285	806	1786	4235	7415	15252	47988	2.65E+05	7.51E+05	2.07E+06	5.85E+06	1.05E+07	1.46E+07	2.54E+07
0.16666	64	9350	430	1216	2693	6386	11183	23001	72369	4.28E+05	1.39E+06	3.40E+06	8.63E+06	1.39E+07	1.05E+07	4.69E+07
0.08333	66	15000	690	1950	4320	10245	17940	36900	115100	6.53E+05	2.34E+06	5.16E+06	1.40E+07	9.20E+06	1.78E+07	8.09E+07
0.08333	68	23000	1058	2990	6624	15709	27508	56560	178020	4.54E+05	1.51E+06	3.62E+06	9.30E+06	1.33E+07	1.46E+07	5.07E+07
0.16666	72	16000	736	2080	4608	10928	19136	39360	123840	2.27E+05	6.42E+05	1.72E+06	4.27E+06	7.97E+06	1.30E+07	2.03E+07
0.16666	76	8000	368	1040	2304	5464	9568	19680	61920	1.36E+05	3.65E+05	8.73E+05	2.60E+06	4.40E+06	1.02E+07	1.06E+07
0.16666	78	4800	221	624	1302	3276	5741	11808	37152	8.40E+04	2.37E+05	5.25E+05	1.45E+06	2.79E+06	5.70E+06	1.15E+07
0.08333	80	2950	136	384	850	2015	3528	7237	22833	3.83E+04	1.09E+05	2.40E+05	5.69E+05	1.09E+06	2.63E+06	8.83E+06
0.16666	84	1350	62	176	389	922	1615	3321	10449	1.54E+04	4.45E+04	9.75E+04	2.32E+05	4.06E+05	8.49E+05	3.35E+06
0.16666	88	550	25	72	158	376	658	1333	4257	1.42E+04	4.01E+04	8.89E+04	2.11E+05	3.69E+05	7.58E+05	3.05E+06
0.33333	96	500	23	65	144	342	598	1230	3870	8.03E+03	2.22E+04	4.89E+04	1.16E+05	2.03E+05	4.18E+05	1.56E+06
0.33333	104	275	13	36	79	188	329	677	2129	3.09E+03	8.03E+03	1.79E+04	4.20E+04	7.41E+04	1.52E+05	4.78E+05
0.33333	112	100	5	13	29	68	120	246	774	0.00E+00	6.17E+02	6.17E+02	1.85E+03	3.70E+03	7.41E+03	2.41E+04
0.33333	120	5	0	1	1	3	6	12	39							

SINGLE EVENT HYDROGRAPH COORDINATES  
(hours vs cfs)

TABLE 3

Summary of Single Event Sediment Transport Capacity Analyses  
Based on the Copeland Laursen Bed Material Transport  
Capacity Procedure

1080	3087	6637	15743	27782	56953	179194
15512	43834	97160	289764	509253	1129904	1190379
19910	56413	124942	353669	636014	1440232	2235010
12348	35191	77790	184442	345816	810501	2818448
5042	14303	31692	75217	131805	287632	1083475
9158	25978	57365	157692	292980	618235	1217110
13222	37454	82986	226635	437957	909152	2010970
40644	115038	278485	740560	1347585	3027190	4694398
36785	104028	276400	692590	1283840	2080568	3331680
28811	89366	227949	567108	977242	3011907	5012968
44966	155740	356584	943158	1862420	3176455	5323465
92298	321372	731517	1842256	3875880	6428840	10964191
56799	179569	444646	113414	1773251	2035693	5914894
15152	42805	108029	286439	518837	867222	1284456
9184	25930	58340	168960	303226	661044	919234
10187	28611	63744	168552	323410	684215	1694066
4476	12759	28142	66780	124533	280285	1015284
4939	14097	31075	73880	129238	268049	1067390
3704	10393	22946	54535	95365	196224	768622
1852	5042	11113	26341	46201	94973	339226
514	1441	3087	7306	12965	26547	83655

BED MATERIAL LOAD (in TONS) TRANSPORTED DURING 5 DAY EVENT  
4.27E+05 1.32E+06 3.12E+06 8.18E+06 1.22E+07 2.01E+07 5.11E+07

BED MATERIAL LOAD (in cubic yards) TRANSPORTED DURING 5 DAY EVENT  
3.33E+05 1.03E+06 2.43E+06 6.38E+06 9.48E+06 1.57E+07 3.99E+07

BED MATERIAL LOAD (in acre-feet) TRANSPORTED DURING 5 DAY EVENT  
2.13E+02 6.61E+02 1.56E+03 4.09E+03 6.08E+03 1.01E+04 2.56E+04

TOTAL LOAD<sup>1</sup>(AF)/EVENT  
245 760 1794 4704 6992 11,615 29,440

<sup>1</sup>TOTAL LOAD = BED MATERIAL LOAD + 15% for WASH LOAD (in acre-feet (AF))

TABLE 3  
(continued)

COPELAND LAURSEN  
BED MATERIAL LOAD JUST ABOVE HIGHWAY 58

QS5	QS10	QS20	QS50 (tons/day)	QS100	QSspf	QSpmf
8.45E+02	2.98E+03	5.91E+03	1.44E+04	2.53E+04	5.20E+04	1.63E+05
2.11E+03	5.49E+03	1.22E+04	2.87E+04	5.07E+04	1.04E+05	3.27E+05
8.28E+04	2.34E+05	5.20E+05	1.67E+06	2.96E+06	5.09E+06	1.01E+07
2.62E+04	7.43E+04	1.64E+05	3.89E+05	7.10E+05	1.97E+06	5.47E+06
7.60E+03	2.29E+04	4.86E+04	1.15E+05	2.02E+05	4.16E+05	1.81E+06
1.31E+04	3.67E+04	8.15E+04	1.93E+05	3.38E+05	7.35E+05	1.00E+06
6.21E+04	1.76E+05	3.89E+05	1.13E+06	2.28E+06	4.33E+06	1.01E+07
4.65E+04	1.32E+05	2.92E+05	7.28E+05	1.64E+06	3.39E+06	8.50E+06
1.20E+05	3.40E+05	8.37E+05	2.49E+06	4.13E+06	7.38E+06	8.31E+06
1.82E+05	5.14E+05	1.51E+06	3.65E+06	5.79E+06	9.61E+06	5.42E+06
2.91E+05	9.59E+05	2.54E+06	5.38E+06	8.34E+06	9.63E+06	6.05E+06
4.47E+05	1.73E+06	3.78E+06	7.78E+06	1.07E+07	7.29E+06	7.02E+06
3.11E+05	1.03E+06	2.69E+06	5.68E+06	8.64E+06	9.34E+06	6.17E+06
1.55E+05	4.39E+05	1.22E+06	3.15E+06	5.08E+06	8.78E+06	6.66E+06
9.33E+04	2.64E+05	5.84E+05	1.94E+06	3.30E+06	6.07E+06	9.60E+06
5.74E+04	1.62E+05	3.59E+05	1.01E+06	2.11E+06	4.06E+06	9.57E+06
2.62E+04	7.43E+04	1.64E+05	3.89E+05	7.10E+05	1.97E+06	5.47E+06
1.06E+04	3.04E+04	6.67E+04	1.59E+05	2.78E+05	5.71E+05	2.51E+06
9.71E+03	2.75E+04	6.08E+04	1.44E+05	2.53E+05	5.20E+05	2.30E+06
5.49E+03	1.52E+04	3.34E+04	7.94E+04	1.39E+05	2.86E+05	1.09E+06
2.11E+03	5.49E+03	1.22E+04	2.87E+04	5.07E+04	1.04E+05	3.27E+05
0.00E+00	4.22E+02	4.22E+02	1.27E+03	2.53E+03	5.07E+03	1.65E+04

COPELAND LAURSEN  
BED MATERIAL LOAD IN UPSTREAM SUPPLY REACH

QS5	QS10	QS20	QS50 (tons/day)	QS100	QSspf	QSpmf
1.19E+03	4.16E+03	8.31E+03	2.02E+04	3.56E+04	7.30E+04	2.30E+05
2.97E+03	7.72E+03	1.72E+04	4.04E+04	7.13E+04	1.46E+05	4.60E+05
1.16E+05	3.30E+05	7.30E+05	1.93E+06	3.39E+06	6.39E+06	2.12E+07
3.68E+04	1.05E+05	2.31E+05	5.48E+05	1.00E+06	2.22E+06	6.36E+06
1.07E+04	3.09E+04	6.83E+04	1.62E+05	2.84E+05	5.84E+05	2.08E+06
1.84E+04	5.17E+04	1.15E+05	2.72E+05	4.76E+05	1.02E+06	3.43E+06
8.73E+04	2.47E+05	5.48E+05	1.41E+06	2.59E+06	5.02E+06	1.46E+07
6.53E+04	1.85E+05	4.10E+05	1.02E+06	1.90E+06	3.86E+06	1.03E+07
1.69E+05	4.79E+05	1.12E+06	2.87E+06	4.73E+06	8.68E+06	3.36E+07
2.55E+05	7.22E+05	1.77E+06	4.14E+06	6.72E+06	1.33E+07	5.67E+07
4.10E+05	1.24E+06	2.92E+06	6.26E+06	9.98E+06	2.44E+07	1.02E+08
6.28E+05	1.99E+06	4.29E+06	8.90E+06	1.68E+07	4.07E+07	1.67E+08
4.37E+05	1.33E+06	3.09E+06	6.59E+06	1.06E+07	2.65E+07	1.11E+08
2.19E+05	6.18E+05	1.49E+06	3.60E+06	5.94E+06	1.08E+07	4.57E+07
1.31E+05	3.71E+05	8.33E+05	2.19E+06	3.76E+06	7.02E+06	2.46E+07
8.08E+04	2.28E+05	5.05E+05	1.29E+06	2.37E+06	4.66E+06	1.31E+07
3.68E+04	1.05E+05	2.31E+05	5.48E+05	1.00E+06	2.22E+06	6.36E+06
1.48E+04	4.28E+04	9.38E+04	2.23E+05	3.91E+05	8.12E+05	2.88E+06
1.37E+04	3.86E+04	8.55E+04	2.03E+05	3.55E+05	7.30E+05	2.62E+06
7.72E+03	2.14E+04	4.69E+04	1.12E+05	1.93E+05	4.02E+05	1.37E+06
2.97E+03	7.72E+03	1.72E+04	4.04E+04	7.13E+04	1.46E+05	4.60E+05
0.00E+00	5.94E+02	5.94E+02	1.78E+03	3.56E+03	7.13E+03	2.32E+04

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BED MATERIAL LOAD (in TONS) TRANSPORTED DURING 5 DAY EVENT  
4.10E+05 1.21E+06 2.76E+06 6.36E+06 1.09E+07 2.37E+07 9.07E+07  
BED MATERIAL LOAD (in cubic yards) TRANSPORTED DURING 5 DAY EVENT  
3.20E+05 9.44E+05 2.15E+06 4.96E+06 8.53E+06 1.85E+07 7.07E+07  
BED MATERIAL LOAD (in acre-feet) TRANSPORTED DURING 5 DAY EVENT  
2.05E+02 6.05E+02 1.38E+03 3.18E+03 5.47E+03 1.18E+04 4.53E+04  
TOTAL LOAD(AF)/EVENT  
236 696 1587 3657 6291 13,570 52,095

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BED MATERIAL LOAD (in TONS) TRANSPORTED DURING 5 DAY EVENT  
2.92E+05 9.24E+05 2.23E+06 5.36E+06 8.73E+06 1.33E+07 2.08E+07  
BED MATERIAL LOAD (in cubic yards) TRANSPORTED DURING 5 DAY EVENT  
2.28E+05 7.21E+05 1.74E+06 4.18E+06 6.81E+06 1.04E+07 1.62E+07  
BED MATERIAL LOAD (in acre-feet) TRANSPORTED DURING 5 DAY EVENT  
1.46E+02 4.62E+02 1.12E+03 2.68E+03 4.37E+03 6.67E+03 1.04E+04  
TOTAL LOAD(AF)/EVENT  
168 531 1288 3082 5026 7670 11,960



Harvey (1989) estimates that there may have been approximately 9 inches of sediment deposited in the reach upstream from the Highway 58 crossing during the 1983 flood event. That event is estimated to be approximately a 2% chance (50 year) event according to the Kern County Water Agency. Comparing the total sediment loads computed in the supply reach with the total load just above the Highway 58 Bridge from the Copeland Laursen method (presented in **Table 3**), it is seen that there is approximately 575 acre feet more sediment transported into subreach 2 from the supply reach (subreach 1) than leaves the reach through the bridge opening. The approximate surface area of reach 2 above the bridge is one square mile (640 acres). Assuming that the 575 acre feet of sediment deposits uniformly over subreach 2, that would give an approximate sediment deposition thickness of 10.8 inches. This matches the observed deposition depth for a 2% chance (50 year) event reasonably well.

During the 1983 flood event, Mr. Malouf, of the Edison Sand Company, Inc. collected grab samples of the suspended load and determined that approximately 30 to 40 percent by volume was sediment (personal communication with Mr. Gerald Malouf, November, 1989). Sediment concentrations computed with the Copeland Laursen method are on the order of 20 to 30 percent for most flows evaluated, indicating good correlation with the observed concentrations measured by Malouf (1989) during the 1983 event.

News video footage taken during the 1983 flood event from the Highway 58 Bridge indicates the likely presence of hyperconcentrated flows in the Caliente Wash during the flood. Hydraulic bores and standing waves indicated that the bed forms were changing rapidly from dunes to antidunes, to a flat bed and back to dunes again. This type of bed form change, transports tremendous amounts of bed material. Traditional bed material transport functions often underestimate the total load being transported for the kinds of hydraulic conditions observed during the 1983 event.

Neither of the two transport function methods accounts for the wash load portion of the total load (which can be significant during high flows), or the contributions from channel bank sloughing, local scour or toe failures that may occur along the Sand Hills deposits near the reservoir site, especially during high flows. Therefore, the higher transport rate per unit discharge computed using the Copeland Laursen method is thought to be more appropriate for the Caliente Wash if we consider all of the other sediment sources that are not directly accounted for by traditional bed material load transport functions.

#### **4.3 Discussion of Single Event Results**

**Table 4** presents the computed sediment inflow to the reservoir from subreach 3 for the various flood events for both transport methods. The 1% chance (100 year) flood event can possibly produce enough sediment during the single design event to remove 43.7 percent of the gross pool storage capacity (6992 AF according to the Copeland Laursen method) or as little as approximately 4.1 percent of the gross pool storage (654 AF according to the New Laursen method). An independent consulting report prepared for the Kern County Water Agency (SLA, 1989) estimates approximately 8,700 acre feet of sediment delivery for a 1% chance (100-year) event. This represents approximately 54 percent of the planned detention storage volume (16,000 acre feet) for the reservoir. The data presented in **Table 4** also suggests that events greater than about the 7.5% chance

**TABLE 4**

**Computed Single Event Sediment Inflow to the Proposed  
Reservoir and Comparison to Planned Detention  
Storage Volume of 16,000 Feet**

% Change of Exceedance Event	New Laursen Method <sup>1</sup>		Copeland Laursen Method <sup>1</sup>	
	Total Load/Event (Ac-ft, dry volume)	Percent of the Planned Detention Storage Volume Associated with Single Event Sediment Delivery	Total Load/Event (Ac-ft, dry volume)	Percent of the Planned Detention Storage Volume Associated with Single Event Sediment Delivery
20 (5-yr)	24.3	<1%	245	1.5%
10 (10-yr)	69	<1%	760	4.8%
5 (20-yr)	158	1%	1794	11.2%
2 (50-yr)	400	2.5%	4709	29.4%
1 (100-yr)	654	4.1%	6992	43.7%
SPF	1253	7.8%	11,615	72.3%
PMF	3990	25%	29,440	184%

<sup>1</sup>Total Bed Material Load Transport Function Used

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**Results from the Kern County Water Agency Report (SLA, 1989)**

Event: 1% chance flood event

Methodology Used: SLA used a combination of the Meyer-Peter Muller and Einstein Transport Functions with an adjustment for high concentrations of suspended material

Computed Total Sediment Load Per Event (acre-feet): **8,700 AF [dry volume]**

Percent of the Planned Detention  
Storage Volume Associated with the  
1% Chance Flood Event Sediment Delivery: **54%**

(15 year) event can possibly remove 10 percent or more of the gross pool storage in one 5 day period. The HEC computed total sediment loads account for the total bed material load with an additional 15 percent added for the wash load.

Typical wash loads can account for as much as 90 to 95 percent of the total load in most sand bed rivers (Vanoni, 1975). However, in the Caliente River Basin the availability of fines (silts and clays) may be limited due to the nature of the granitic parent materials throughout the basin (see Harvey, 1989). HEC postulates that the wash load near the damsite will have an inverted bed load/wash load relationship, and may only account for approximately 15 percent of the total sediment load being transported by each event. This is based on the stratigraphic information from the Corps of Engineers boring data near the damsite, the bed material samples collected in field and the field observations showing the lack of thick soil horizons or mud drapes. It is possible, however, that for the less frequent, large discharge events (greater than 2% chance events), considerably more wash load than 15 percent of the total load is possible. If the actual wash load accounted for 50 to 75 percent of the total load, then the actual volume of sediment transported into the reservoir during a 1% chance (100-year) storm could be as high as 9,120 to 10,640 AF/event, respectively. These volumes represent 57 and 66.5 percent of the planned detention storage volume of the reservoir. Measured suspended sediment concentrations as high as 30 to 40 percent by volume have been observed during large flood events in Caliente Creek near Highway 58. This is another good reason to utilize the larger total bed material load values computed with the Copeland Laursen method. Vanoni (1975) shows that with high fine sediment concentrations in the flow, the transport capacity of coarser sized materials (sand and gravel) increases.

Large events such as a 2% chance (50 year) flood or greater may produce large amounts of sediment material that enter the water course due to mass wasting, channel bank failure and erosion of prograded alluvial fans that often extend into the channel in the upper basin. It may be that single event sediment production can contribute sufficient quantities of sediment materials to the reservoir in a short period of time (a few days) and affect the operation and storage characteristics of the project.

## **5. Discussion of Other Concerns**

Consideration is being given for the closure of the eastern bridge opening under Highway 58 in order to avoid flow short circuiting directly into the emergency spillway. Consideration is also being given to the installation of a setback levee along the left overbank in the floodplain area upstream from the spillway to further ensure that flood flows will enter the reservoir and not the spillway directly. Focussing the flow energies along the toe of the high Sand Hills may lead to sloughing of the high bank into the channel upstream from the reservoir (some problems presently exist as a result of flows that nicked the toe during the 1983 flood event). Depending on the magnitude of the bank failure, large blocks of sandy and gravelly material could enter the reservoir almost instantaneously. Field observations during the October 1989 field inspection show the existence of two large slide areas that probably occurred during the 1983 event as a result of toe scour at the base of the Sand Hills. The estimated volume of material associated with each of these slips is approximately 75 to 100 AF. Much larger soil slips are possible and could potentially occur along the entire length of the Sand Hills if the toe is not

protected from high flows. This could introduce approximately 500,000 cubic yards (265 acre feet) of loose sediment materials into the channel to be carried directly into the reservoir during a large event. Soils stabilization and grouting along the Sand Hills abutment section may be necessary.

Preliminary hydraulic analyses indicate that the Highway 58 crossing will be overtopped by large events greater than the 1% chance (100 year) event. The potential for this increases if future plans call for the closure of the eastern bridge opening. The highway embankment is not designed to be overtopped and would most likely fail. Failure of the highway embankment could possibly fail the Sivert Dam two miles downstream.

The basin wide sediment yields presented in this report do not account for possible increases in sediment yield from increasing urbanization, the possibility of forest fires, future road building, future dust storms (aeolian transport) such as occurred in the late 1970's or continued overgrazing of the watershed. The occurrence of a major forest fire or a large dust storm could easily produce sufficient sediment in the basin to increase the annual sediment yield by 2 to 5 times for a period of approximately 10 to 15 years until the basin "heals."

The Highway 58 embankment presently acts like a sediment retention dam by reducing the local sediment transport capacity just upstream from the highway embankment. Field evidence shows that sediment is depositing slowly upstream from the embankment, however, at the lowest point along the highway embankment (at elevation 755), the Caliente Wash elevation is only 2 feet lower than the road elevation (elevation 753). High velocity (approximately 6 to 8 fps) flows during a flood aimed at the low point in the highway could ramp up the 2 to 3 feet and flow over the highway, possibly damaging the embankment or even leading to its failure. Flows impinging on the embankment must turn abruptly and flow parallel to the embankment toward the western bridge opening to get to the reservoir. Unless sufficient bank protection is provided, toe scour along the embankment may also cause damage to the highway and contribute to the overall increase in sediment delivered to the reservoir.

With the reservoir pool full or partially full, an earthquake could induce a mass wasting failure of the high Sand Hills embankment into the reservoir, thus possibly displacing a large volume of water over the top of the reservoir embankment. Such an overtopping occurrence might lead to the failure of the earthen dam itself. Dam safety analyses may be required during future studies.

Locating the dredged sediment drying and spoiling operation (reservoir maintenance dredging) just upstream from the reservoir needs to be reevaluated. Placement of loose dredged materials in the active channel area may lead to dredging of the same materials over again along with those fresh materials that flow in during an event. The conditions inside the reservoir following a large storm event will be extremely wet and muddy. Traditional rubber tire excavators will be unable to operate in the reservoir area. More costly excavation and dredging methods may be necessary in order to remove accumulated sediment from the reservoir prior to the next rainy season.

Present estimates indicate a possible 250 cfs of infiltration losses through the reservoir bottom. Sizing of the gross pool capacity should not depend on infiltration losses to decrease the storage volume requirements in the reservoir or the outlet capacity necessary to safely release stored water. Sufficient fines may enter the reservoir during an event and seal up the bottom, thus reducing or eliminating infiltration losses.

Design of the low level outlet needs to be reevaluated. The present (feasibility) design calls for a single grated outlet pipe at the bottom of the reservoir near the toe of the dam. Sediment and debris entering the reservoir can clog the outlet, thus rendering it inoperative.

Local scour depths at the Highway 58 Bridge need to be computed for the increased flows that will occur due to the closure of the eastern opening. Harvey (1989) points out that the present natural slope of the Caliente wash is slightly west to east above the bridge. Therefore, high flows may concentrate along the eastern side of the floodplain, thus reducing the hydraulic efficiency of the single bridge opening on the west side of the valley.

Ponding of flood waters upstream from the bridge embankment due to the closure of the eastern opening may cause additional flooding problems for the present landowner located upstream from the Highway. Easements, or other precautionary agreements may be necessary to avoid law suits stemming from modification to the present drainage.

Capture of fluvial sediments in the reservoir and release of relatively clear water from the reservoir into downstream channels must be considered with respect to the stability of the downstream channels. Evaluation of downstream channel stability should be part of the Phase II SEI investigations.

## 6. Conclusions

The following conclusions are drawn from the results of this investigation:

- 1) The morphology of the Caliente Creek drainage basin and the nature of the sediments delivered to the channels and the potential for sediment storage within the drainage basin are controlled by basin geology (Harvey, 1989).
- 2) Sediment transport in the basin is episodic and depends on the occurrence of large runoff events. Sediment is stored in the broad valley washes (3,000 to 6,600 feet wide) in the lower portions of the Caliente Basin. There is sufficient material located in these expansive washes to provide sediment supply to the lower fan areas somewhat independently of the production and delivery of sediments from the upper watershed areas. Therefore, sediment yield at the proposed damsite may be more dependent upon the transport capacity of the channels and washes upstream from the damsite, than the watershed production of sediment materials during a flood event.
- 3) Examination of the results from eight different sources of yield data and methods for estimating yield at the damsite concludes that the approximate average annual sediment yield at the Sivert Reservoir is 0.75 AF/sq mi/yr. This

represents approximately 353 acre feet of sediment each year. Computed and measured annual sediment yields (dry volume) ranged from 0.2 AF/sq mi/yr to approximately 0.97 AF/sq mi/yr for basins larger than 390 square miles.

- 4) Simons, Li and Associates, Inc. conducted an independent analysis for Kern County Water Agency to develop the average annual and 1% chance (100-year) flood sediment yields. They concluded that the average annual sediment yield may range from 0.51 AF/sq mi/yr to 1.42 Af/sq mi/yr. For the 1% chance flood, the estimated sediment delivery to the reservoir was approximately 8,700 acre feet (dry volume). This represents approximately 54 percent of the planned detention storage volume (16,000 acre feet) and 37 percent of the proposed spillway design flood pool (23,500 acre feet).
- 5) Single event floods may produce significantly more sediment per event than the annual sediment yield indicates. As much as 43 percent (Corps of Engineers estimates) of the total gross pool storage volume (16,000 AF) may be lost due to sediment deposition during a 1% chance (100 year) event. This would necessitate the removal of approximately 6,990 AF of sediment material (dry volume) from the reservoir prior to the next flood season.
- 6) The present (feasibility) reservoir design requires the concentration of flow along the toe of high Sand Hills (along the western margin of the lower Caliente Creek incised fan). Flood flows in 1983 barely nicked the toe of the Sand Hills in two places causing mass failure of the banks onto the floodplain. Concentrating future flood flows along the toe may lead to the failure of large sections of embankment along the Sand Hills and significantly increase the volume of sediment entering the reservoir during an event. This could further reduce the water storage capacity of the reservoir.
- 7) A detailed hydraulic evaluation of the Highway 58 bridge opening located at the western side of the valley needs to be conducted. Present plans require the closure of the east side opening, thus flood flows are concentrated through one opening instead of two. Pier scouring, embankment erosion and possible overtopping of the highway are of concern.
- 8) Design of the low-level outlet, along with the spillway apron and chute channel need reevaluation. The stability of channels downstream from the reservoir must also be considered.
- 9) Forest fires, urbanization, future road building and the possibility of aeolian sand storms may increase the annual sediment yield to the reservoir site for many years following any one of these kinds of occurrences. Cumulative effects from several such occurrences are difficult to estimate.
- 10) Field circumstantiation of the estimated annual sediment yield is possible via field logging in a network of deep trenches.

## References

1. Bailey, Paul (1943). "Report on Protection of the Lands Within the Arvin-Edison Water Storage District," Paul Bailey - Civil and Consulting Engineer, Santa Ana, CA.
2. Boyle Engineering Corporation (1977). "Preliminary Engineering Report on Caliente Creek - East Side Canal Drainage Plan for Lamont Area," Boyle Engineering Corporation - Consulting Engineers and Architects, Bakersfield, CA.
3. California Field Office (1979). "A Master Plan Inventory for the Sand Ridge Preserve," The Nature Conservancy, San Francisco, CA.
4. Dendy, F.E. and G.C. Bolton (1976). "Sediment Yield - Drainage Area Relationships in the United States," Journal of Soil and Water Conservation.
5. Dibblee, Thomas W. and Warne, Archer H. (1988). "Inferred Relation of the Oligocene to Miocene Bealville Funglomerate to the Edison Fault, Caliente Canyon Area," Studies of the Geology of the San Joaquin Basin, Pacific Section, S.E.P.M., Vol. 60, pp. 223-231.
6. Graham, S.A., Carroll, A.R. and Miller, G.E. (1988). "Kern River Formation as a Recorder of Uplift and Glaciation of the Southern Sierra Nevada," Studies of the Geology of the San Joaquin Basin, by Graham, Stephan A. Pacific Section S.E.P.M., Vol. 60, pp. 319-331.
7. Harvey, Michael (1989). "Caliente Creek, California Project Geomorphic Analyses," Draft Report prepared by Water Engineering & Technology, Inc. Contract No. DACW05-88-D-0044, Delivery Order No. 0011, Fort Collins, CO.
8. Jenks, James S. and Pyle, Stewart T. (1989). "Caliente Creek Flood Control Project - Infiltration Losses for Designated Floodways," Leedshill-Herkenhoff, Inc. Open-File Report, San Francisco, CA.
9. Kern County Water Agency (1966). "Report on Flooding of Caliente Creek - December 5 to 7, 1966," Kern County Water Agency, Bakersfield, CA.
10. Kern County Water Agency (1972). "Caliente Creek Stream Group - Flood Control Report," Kern County Water Agency, Bakersfield, CA.
11. Kern County Water Agency (1976). "Kern County Water Agency Flood Damage Reduction Program," Kern County Water Agency, Bakersfield, CA.
12. Kern County Water Agency (1985). "Cooperative Stream Gaging Program," Kern County Water Agency, Bakersfield, CA.
13. Leedshill-Herkenhoff, Inc. (1985). "Caliente Creek Flood Control Plan," Caliente Creek Flood Control Task Force - Kern County, Leedshill-Herkenhoff, Inc. Consulting Engineers, San Francisco, CA.

14. Pacific Southwest Inter-Agency Committee (1968). Report of the Water Management Subcommittee on "Factors Affecting Sediment Yield in the Pacific Southwest Areas and Selection and Evaluation of Measures for Reduction of Erosion and Sediment Yield," Sedimentation Task Force, PSIAC.
15. Nakato, Tatsuaki (1990). "Tests of Selected Sediment-Transport Formulas," Journal of Hydraulic Engineering, Vol. 116, No. 3, March, ASCE, New York, NY, pp. 362-379.
16. Rick Engineering Company (1986). "Flood Insurance Study - Kern County," Federal Emergency Management Agency, San Diego, CA.
17. Simons, Li & Associates, Inc. (1989). "Sedimentation Study of Caliente Creek Watershed Kern County, CA", a report prepared for the Kern County Water Agency, dated 3 November 1989, Bakersfield, California.
18. State of California, Department of Natural Resources (1955). "Earthquakes in Kern County, California During 1952," Bulletin 171, San Francisco, CA.
19. State of California, Department of Public Works (1933). "Report on Flood of September 30, 1932 on Tehachapi," State of California - Division of Water Resources, Sacramento, CA.
20. State of California, Department of Public Works (1947). "Report on Control and Utilization of Flood Waters in Kern County," State of California Division of Water Resources, Sacramento, CA.
21. State of California, Department of Transportation (1957). "Preliminary Bridge Report for the Caliente Creek Bridges," Department of Transportation - District 6 Open-File Report VI-Ker-58-67.3, Fresno, CA.
22. Stearns, C.E. (1978). "Antelope and Blackburn Damsites, Tehachapi Watershed, Tehachapi, California," Engineering and Geology Report, U.S. Department of Agriculture, Soil Conservation Service.
23. U.S. Army Corps of Engineers (1966). "Review Report for Flood Control on Caliente Creek Stream Group - Kern County," Sacramento District, Sacramento, CA.
24. U.S. Army Corps of Engineers (1979). "Caliente Creek Stream Group - Environmental Inventory," Sacramento District, Sacramento, CA.
25. U.S. Army Corps of Engineers (1980). "Caliente Creek Stream Group - Hydrology," Sacramento District, Sacramento, CA.
26. U.S. Army Corps of Engineers (1986). "Laboratory Soils Testing," Engineering Manual EM 1110-2-1906, Office of the Chief of Engineers, Washington, D.C.
27. U.S. Army Corps of Engineers (1988-a). "Caliente Creek Stream Group Investigation, California," Documentation Report, Sacramento District, Sacramento, CA.



28. U.S. Army Corps of Engineers (1988-b). "Feasibility Report and Environmental Impact Statement," Caliente Creek Stream Group Investigation, California, Sacramento District, Sacramento, CA.
29. U.S. Army Corps of Engineers (1989). "Sedimentation Investigations of Rivers and Reservoirs; Engineering Manual EM 1110-2-4000, Office of the Chief of Engineers, Washington, D.C.
30. U.S. Army Corps of Engineers (1989). "Plan of Action and Schedule of Activities," Caliente Creek Stream Group Investigation, California, Sacramento District, Sacramento, CA.
31. U.S. Army Corps of Engineers (1989). "Plan of Action - Caliente Creek, CA," Sacramento District, Sacramento, CA.
32. U.S. Department of Agriculture (1975). "Erosion, Sediment and Related Salt Problems and Treatment Opportunities," Special Projects Division, Soil Conservation Service, Golden, CO.
33. U.S. Department of Agriculture (1977). "Supplement to Sediment Deposition in U.S. Reservoirs: Summary of Data Reported Through 1975," Miscellaneous Publication No. 1362 compiled by the Sedimentation Committee, Water Resources Council at the USDA Sedimentation Laboratory, Oxford, MS.
34. U.S. Department of Agriculture (1980). "Watershed Plan and Environmental Impact Statement - Tehachapi Watershed," Soil Conservation Service, Tehachapi, CA.
35. U.S. Department of Agriculture and University of California Agricultural Experiment Station (1981). "Soil Survey of Kern County, California - Southeastern Part," Soil Conservation Service, Tehachapi, CA.
36. U.S. Department of the Interior and California Department of Boating and Waterways (1988). "Sediment Loads in the Ventura River Basin, Ventura County, California, 1969-81," Water-Resources Investigation Report 88-4149, U.S. Geological Survey, Sacramento, CA.
37. Vanoni, Vito A., ed. (1975). Sedimentation Engineering, American Society of Civil Engineers, New York, NY.
38. Williams, David T. and Pierre Y. Julien (1989). "Applicability Index for Sand Transport Equations," Technical Note, Journal of Hydraulic Engineering, Vol. 115, No. 11, Nov 1989, ASCE, New York, NY, pp. 1578-1581.

# **APPENDICES**

## **APPENDIX A**

### **Executive Summary from Harvey (1989)**

## EXECUTIVE SUMMARY (1)

This report presents the results of a Geomorphic Analysis of the Caliente Creek drainage basin in Kern County, California (Fig. 1.1). The investigation was one of two elements of the first phase of a two-phase Sediment Engineering Investigation (SEI) of which the primary objective was to determine the watershed sediment yield upstream of a proposed flood detention reservoir. Significant flood damage has occurred historically on the Caliente fan downstream of the proposed damsite (COE, 1988).

The geomorphic analysis was conducted concurrently with a Sedimentation Analysis performed by the U.S. Army Corps of Engineers Hydrologic Engineering Center and is based on: 1) a field reconnaissance of the watershed, 2) analysis of topographic maps, 3) sediment samples collected in the field and 4) a review of the pertinent scientific and engineering literature. The objectives of the investigation were: 1) to identify specific geomorphic characteristics of the stream channels and watersheds upstream of the proposed detention basin that would affect sediment yield to the detention basin and 2) to relate channel and basin processes to sediment yield for various frequency precipitation and flood flow events.

The morphology of the basin is controlled primarily by the basin geology and structural setting. The lower elevation portions of the basin are composed of Pleistocene and Recent age alluvial fans. Tertiary age non-marine rocks separate the alluvial fans from the majority of the basin that is underlain primarily by quartz diorites. Two active faults, the White Wolf Fault and the Breckenridge Fault, traverse the basin and recent (1952) earthquakes related to these faults have caused significant mass wasting of the slopes in the basin. Weathering of the diorite in a semi-arid climate produces primarily sand size sediment that has a low fines content. The potential for sediment delivery to the proposed reservoir site is controlled by the valley width and channel slopes (Table 3.1). Canyon sections are narrow and have steep slopes that limit the potential for sediment storage; therefore, they act as conveyance sections. Wider valley sections have flatter slopes and substantially increased sediment storage potential. Reaches C1 and C2 (Fig. 3.1) on Caliente Creek and possibly Reach WB1 on Walker Basin Creek (Fig. 3.3) have sufficient sediment stored in them

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(1) from Harvey, Michael (1989)

to be considered as sediment supply reaches for the proposed reservoir regardless of the amount of sediment that is delivered to them by future flood flows.

Channel morphology within the basin is indeterminate. In the canyon sections, channel morphology is controlled by flood flows and in the alluvial sections, the flows are ephemeral. Therefore, the channel morphology reflects the last flow that was experienced. The very high permeabilities of the alluvial sediments (K ranges from 85 to 350 ft./day) cause high infiltration losses (1 cfs per acre inundated) that reinforce sediment deposition in the alluvial reaches.

Dry ravel is an important sediment delivery process in the basin on steep slopes underlain by diorite that have limited ground cover (Plate 1). Debris flows episodically transport valley floor stored sediments in the lower order drainages. Mass failure of colluvial slope deposits delivers significant volumes of sediment to the channels during flood flows (Plate 5). Terraces along the channels and alluvial fans that are located at the confluences of lower order channels and the major channels within the basin can be significant sources of sediment during flood flows. Sediment transport within the basin is episodic and depends to a large extent on the occurrence of flood flows.

Sediment samples collected in the basin channels indicate that, in general, the silt-clay content of the sediments is low, which reflects the basin lithology and the climate (Table 4.1). Bimodal grain size distributions are found in canyon sections (Sample W2) and where flow expansion and sediment deposition have been (Samples S6 and W1). Samples S7 and S10 represent sediments transported by unconfined flows on the Caliente fan. Samples S8, S9, S12 and S13 represent sediments transported by confined, but relatively shallow, flows on the Caliente fan. Shallow flow depths are indicated by the horizontal bedding of the sediments.

Stratigraphic evidence on the Caliente fan (Fig. 6.8; Plates 13 and 14) suggests that an average value for sediment deposition on the fan upstream of the Highway 58 embankment is about 9 inches per flood event. Significant volumes of sediment are being stored on the fan surface upstream of the highway embankment (Fig. 6.1). The highway embankment is acting as a sediment detention structure and may be causing degradation of the western channel on the fan downstream of the highway crossing (Plate 15). Concentration of flows on the western margin of the fan could result

in undercutting of the Pleistocene age fan sediments that form the fan margin (Sand Hills) unless remedial measures are taken. If undercutting occurs, considerable volumes of sediment could be delivered to the proposed reservoir site. Deposition on the western margin of the fan upstream of the highway crossing may cause future flood flows to be concentrated on the eastern side of the fan (Fig. 6.7), in which case there is a possibility that flood flows could bypass the proposed detention structure.

Floods in the Caliente Creek basin have a significant impact on sediment delivery to the proposed reservoir site. Floods are generated both by summer-fall thunderstorms and winter-spring frontal rainstorms. The Standard Project Flood (SPF) for the two types of storms has been computed to be 17,500 cfs and 56,500 cfs, respectively. The presence of different aged and very coarse-grained flood deposits in many of the channels in the basin (Plates 11 and 12) and the fact that the basin characteristics appear to fit the profile for extreme flood discharges (Costa, 1987a, b) suggest that peak discharges in the basin may have been underestimated.

The results of this investigation suggest that there are three areas of concern that have the potential to affect adversely the proposed detention reservoir. First, the possibility exists that peak discharges may have been underestimated. Second, the possibility exists that flood flows may bypass the detention basin if flows become concentrated on the eastern side of the fan. Third, the possibility exists that flood flows could undercut the Sand Hills on the western fan margin, thereby delivering significant volumes of sediment to the proposed detention basin. It is recommended that these areas of concern be investigated further.

## **APPENDIX B**

### **Sediment Sample Gradation Analyses**

Sediment Gradation (Sieve and Hydrometer) Analyses  
Were Conducted Using Standard Laboratory Soils Testing Methods  
As Prescribed By

Engineering Manual 1110-2-1906

Laboratory Soils Testing

Headquarters, Department of the Army

Office of the Chief of Engineers

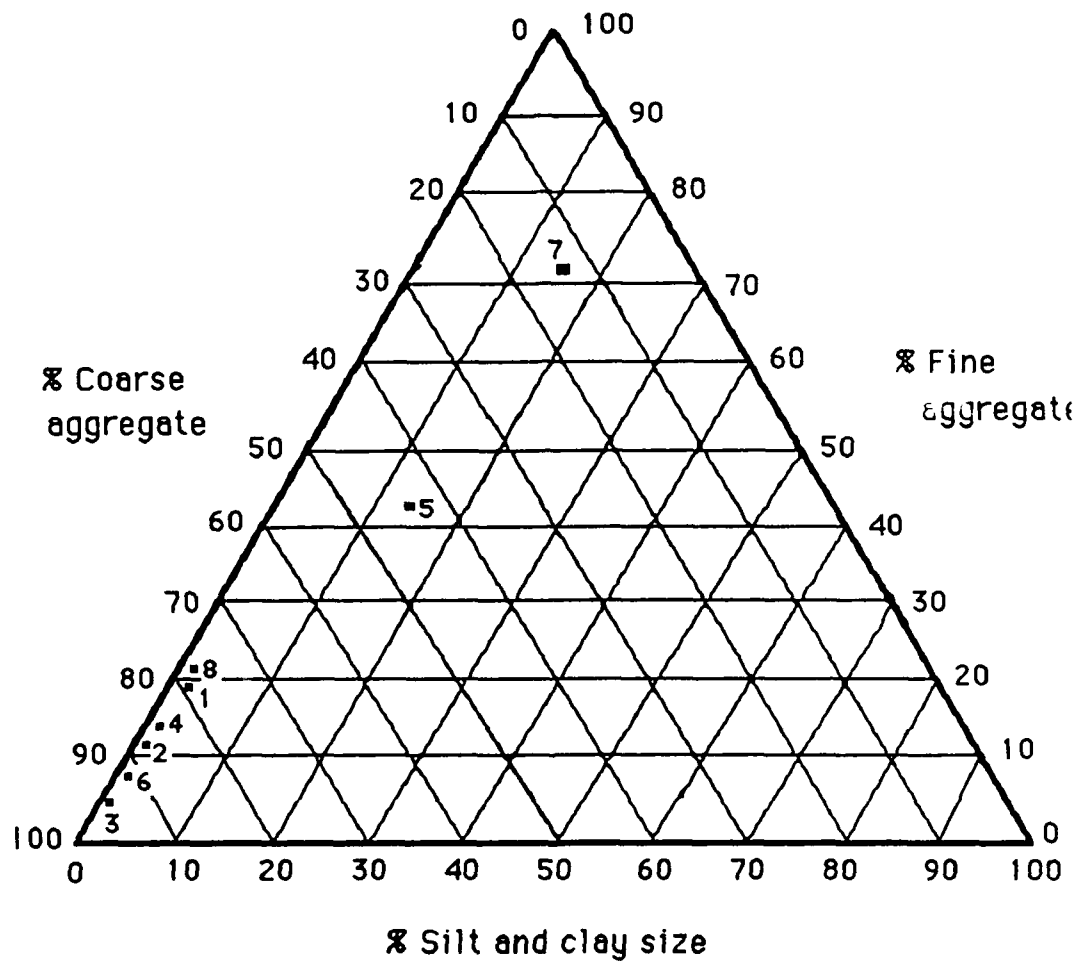
30 November 1970  
(Updated August 1986)

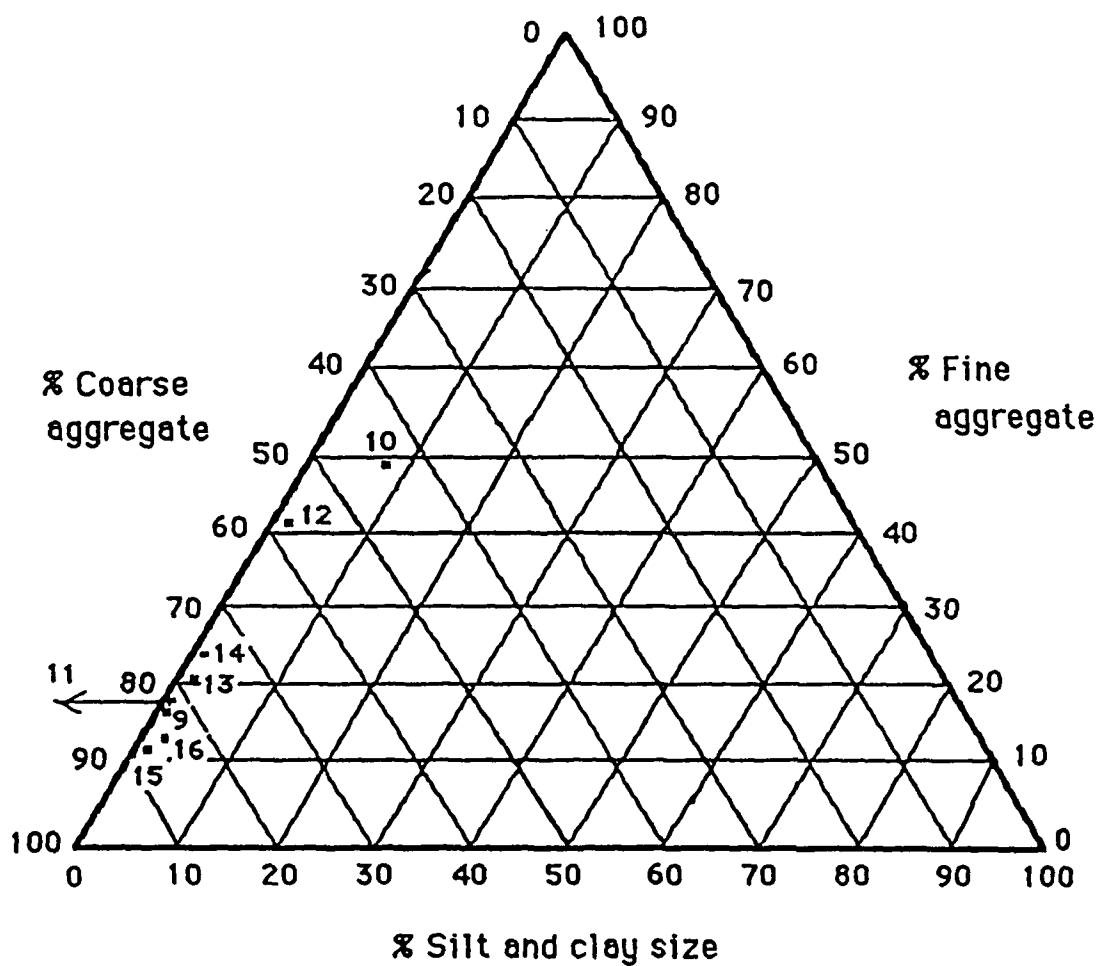


CALENTE CREEK PROJECT

SUMMARY OF THE TEST RESULTS

<u>SAMPLE #</u>	<u>SOIL TYPE</u>	<u>% PASSING #200</u>	<u>GS</u>	<u>% ORGANIC</u>
1	SW	1.89	2.682	0.630
2	GW - SW	2.00	2.760	0.841
3	GW - SW	1.00	2.717	0.652
4	SP	0.50	2.705	0.647
5	SC - SM	13.00	2.702	1.446
6	GW - SW	0.25	2.687	0.421
7	SP	17.00	2.737	1.900
8	SP	0.50	2.690	0.444
9	(SW)-SP	0.70	2.690	0.402
10	SP	9.00	2.737	0.891
11	SW	0.13	2.695	0.436
12	SP	1.50	2.684	0.612
13	(SW)-SP	0.50	2.709	0.598
14	SP	0.25	2.665	0.388
15	SP	1.00	2.806	0.430
16	SW	1.00	2.782	0.630





SAMPLE #9 TO # 16

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S1

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

*Soil Sample Size (ASTM D1140-54)*

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, W <sub>s</sub>	1,430 gram

*Sieve analysis and grain shape*

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
7	2.83	600.0	41.95	58.05
40	0.42	562.5	39.37	18.68
100	0.149	187.0	13.15	5.53
170	0.088	42.0	2.93	2.594
200	0.075	10.0	0.69	1.89
pan	-	28.0	1.95	0.0--

% passing = 100 -  $\sum$  % retained.

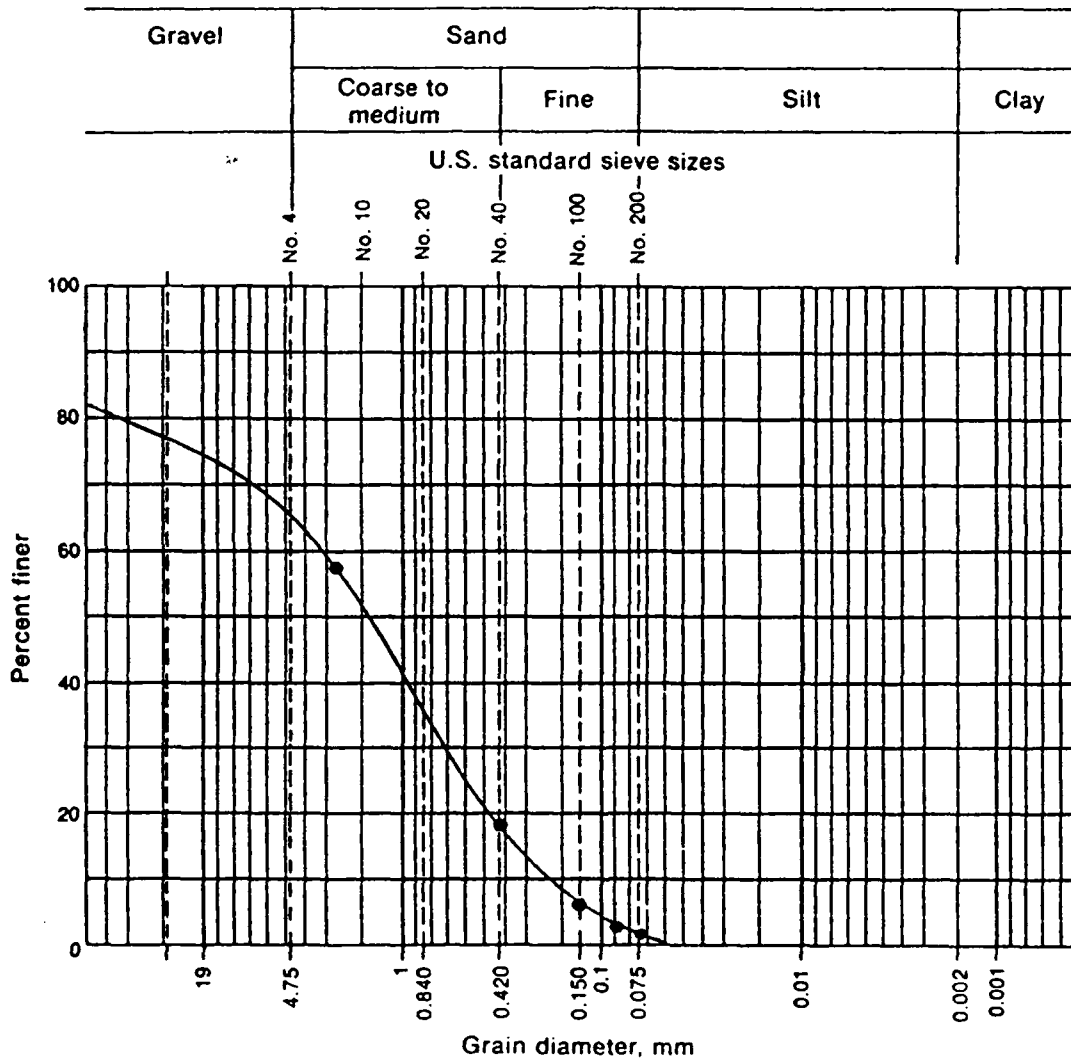
## GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S1

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_

Visual soil description Well graded sand with few gravels  
cu = 15.0

Soil classification:

SW System Unified Soil Classification

Gravels = 36.0 % ; Sands = 62.1 % ; Silts + Clays = 1.89 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S2

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

*Soil Sample Size (ASTM D1140-54)*

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	1,701 gram

*Sieve analysis and grain shape*

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
---	12.50	432.00	25.39	74.61
7	2.83	658.00	38.68	35.93
40	0.42	387.0	22.75	13.18
100	0.149	146.00	8.58	4.60
170	0.088	36.00	2.11	2.49
200	0.075	7.00	0.41	2.07
pan	-	35.00	2.05	0.0--

% passing =  $100 - \sum$  % retained.

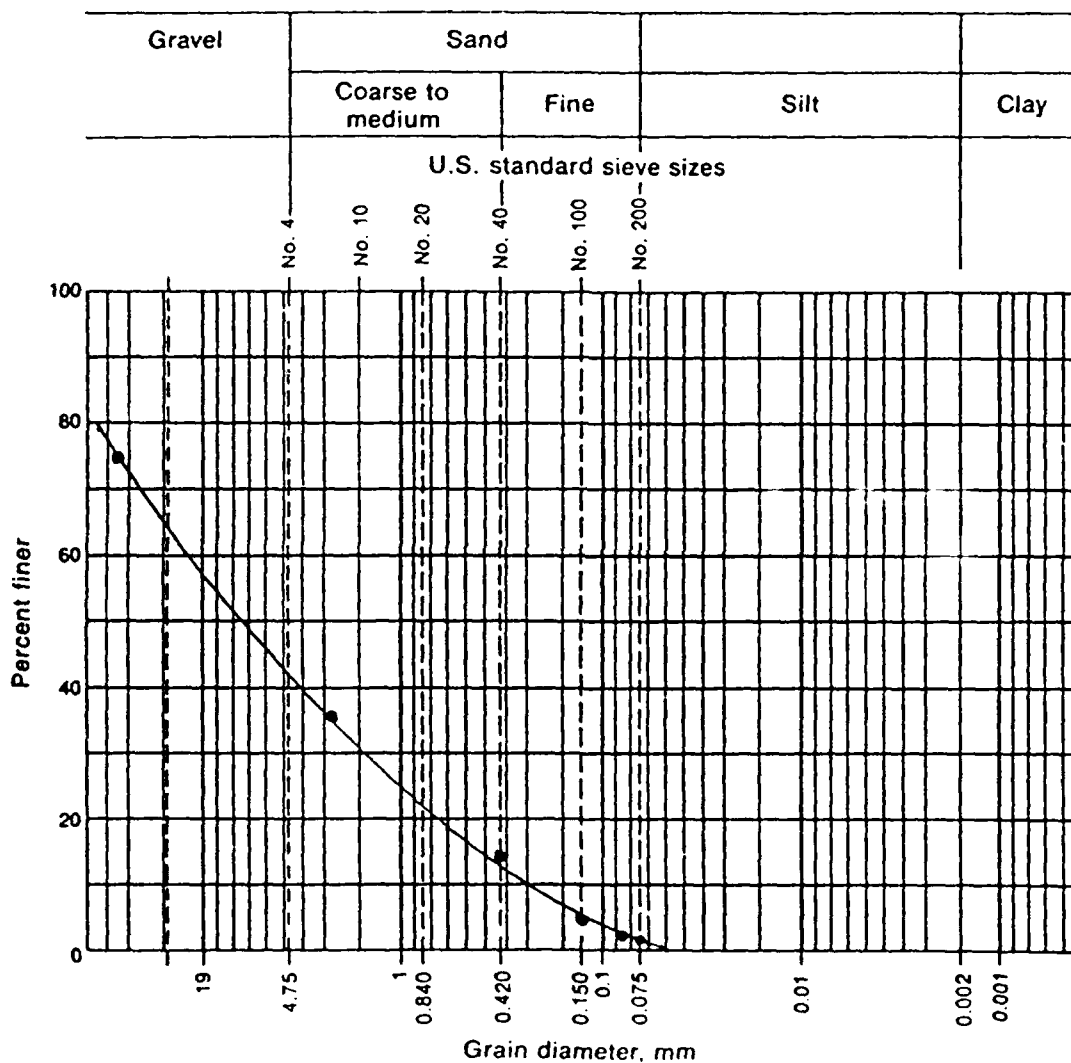
## GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S2

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Well graded gravelly sand

$C_u = 34.66$

Soil classification:

GW-SW

System

Unified Soil Classification

Gravels = 58 % ; Sands = 40 % ; Silts+clays = 2 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S3

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

*Soil Sample Size (ASTM D1140-54)*

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	1,519 gram

*Sieve analysis and grain shape*

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
---	12.50	303.00	19.94	80.06
7	2.83	480.00	31.59	48.47
40	0.42	624.00	41.73	6.74
100	0.149	77.00	5.06	1.68
170	0.088	10.00	0.65	1.03
200	0.075	2.00	0.13	0.90
pan	--	13.0	0.85	-0.0

$$\% \text{ passing} = 100 - \sum \% \text{ retained}$$



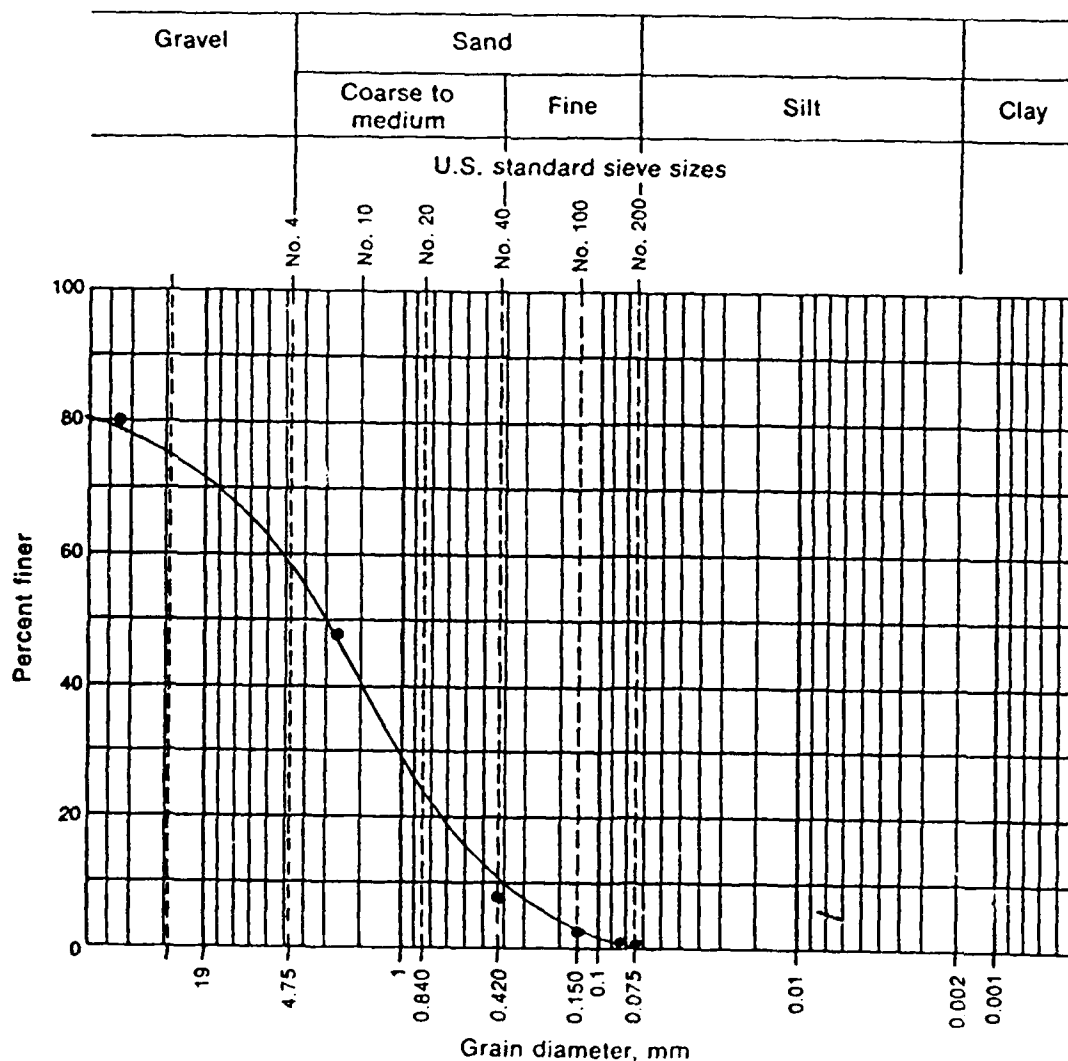
## GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S3

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_

Visual soil description Well graded gravelly sand  
cu = 12.85

Soil classification:

Gw-SW System Unified soil classification

Gravels = 42 % ; Sand = 57 % ; Silts +Clays = 1 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S4

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

*Soil Sample Size (ASTM D1140-54)*

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	962.0 gram

*Sieve analysis and grain shape*

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
30	0.594	599.0	62.26	37.74
40	0.425	216.0	22.45	15.29
100	0.149	135.0	14.03	1.26
170	0.088	6.0	0.623	0.637
200	0.075	1.0	0.10	0.537
pan	--	5.0	0.52	0

% passing =  $100 - \sum$  % retained.

# GRAIN SIZE DISTRIBUTION

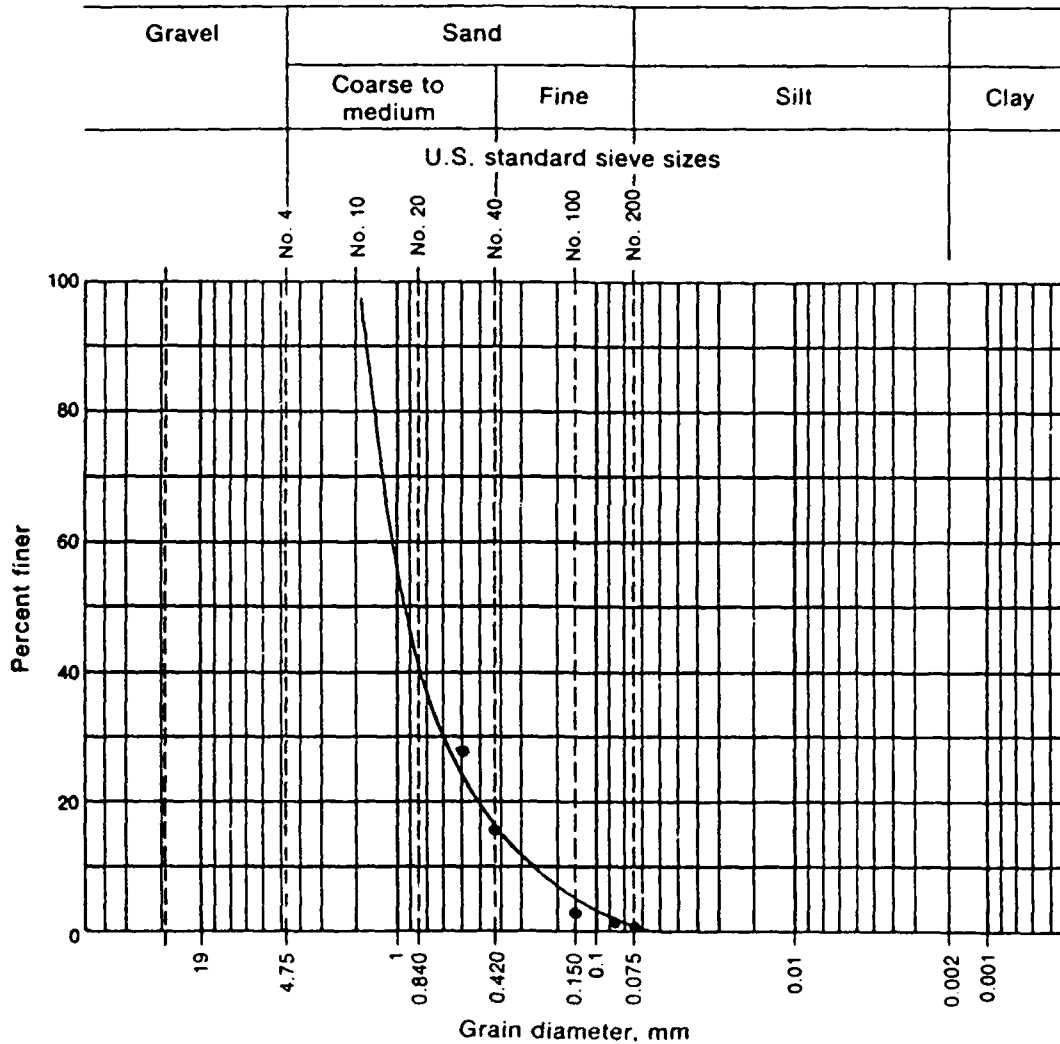
Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S4

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded sans with little fines  
cu = 3.20

Soil classification:

SP System Unified Soil Classification

Gravels = 0 % ; Sands = 99.5 % ; Silts+Clays = 0.5 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S5

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, W <sub>s</sub>	859 gram

## Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
—	6.3	80.0	9.31	90.69
7	2.83	70.0	8.14	82.55
18	1.0	90.0	10.47	72.08
40	0.425	118.0	13.73	58.35
80	0.177	207.0	24.09	34.26
100	0.15	56.0	6.51	27.75
140	0.105	66.0	7.68	20.07
200	0.075	60.0	6.98	13.09
pan	--	112.0	13.03	-0

% passing = 100 -  $\sum$  % retained.

## Data Sheet 7

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Zero correction +4      Meniscus correction +1

[illegible]

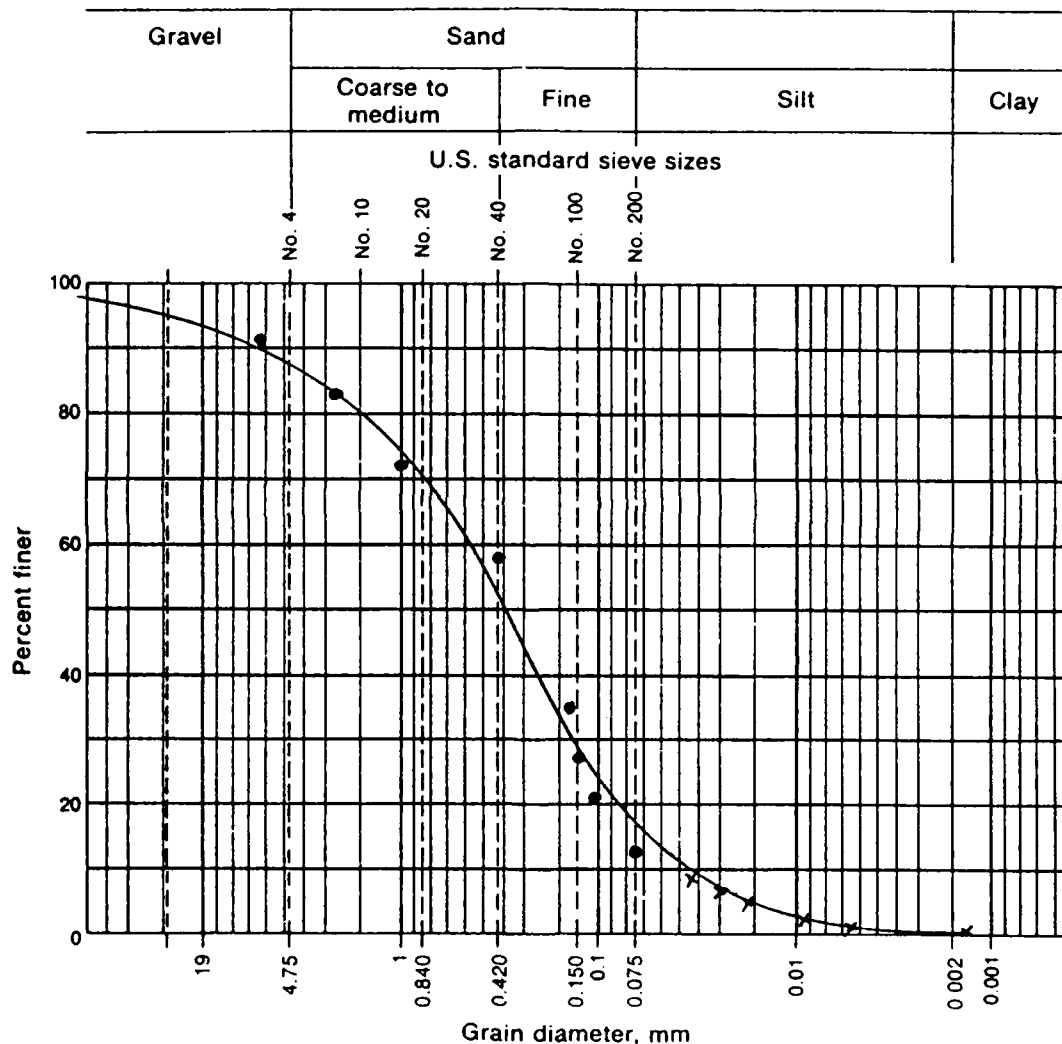
$$D = K\sqrt{L/t}$$

B-14

# GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S5  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded sand with fines,  $c_u = 13.8$

Soil classification:

SC-SM System Unified Soil Classification

Gravels = 12 % ; Sands = 75 % ; Silts+clays = 13 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S6

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	2,098 gram

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
-	12.50	942.50	44.92	55.08
7	2.83	263.50	12.55	42.53
40	0.425	693.0	33.03	9.50
100	0.149	179.00	8.53	0.97
170	0.088	15.00	0.71	0.26
200	0.075	1.0	0.047	0.21
pan	-	4.0	0.19	-0

 $\% \text{ passing} = 100 - \sum \% \text{ retained.}$

# GRAIN SIZE DISTRIBUTION

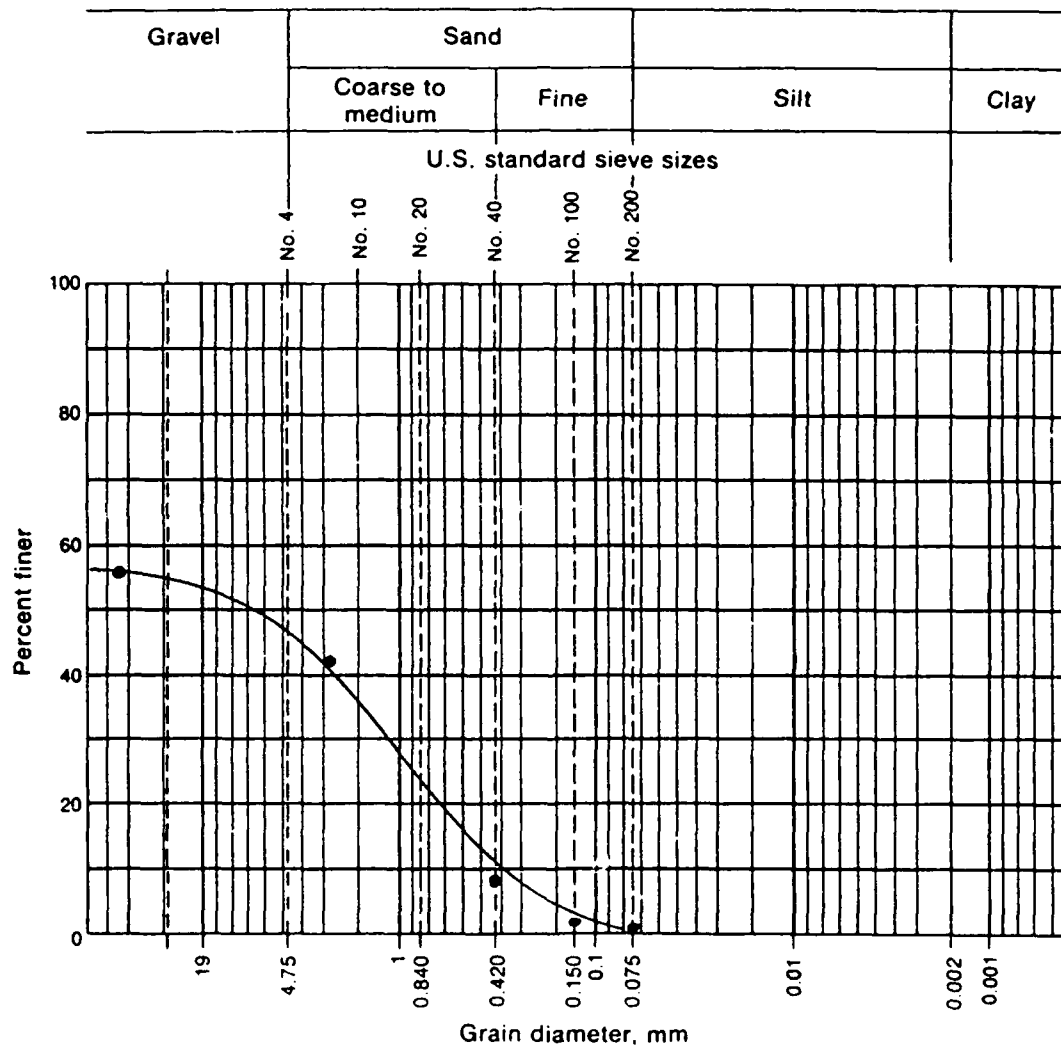
Data Sheet 6

Project CALIENTE Creek Job. No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S6

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Well graded sand with gravels, cu = 34.88

Soil classification:  
GW-SW System Unified Soil Classification

Gravels = 55 % ; Sands = 44.75 % ; Silts +clays= 0.25 %



## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S7

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

## Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, W,	688 gram

## Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
40	0.425	75.0	10.90	89.10
100	0.149	286.5	41.64	47.46
170	0.088	161.0	23.40	24.06
200	0.075	50.0	7.26	16.80
Pan	-	115.5	16.78	-0-

% passing =  $100 - \sum$  % retained.

## Data Sheet 7

**Tested By** \_\_\_\_\_ **Date of Testing** \_\_\_\_\_

Zero correction +4      Meniscus correction +1

[illegible]

$$D = K\sqrt{L/t}$$

# GRAIN SIZE DISTRIBUTION

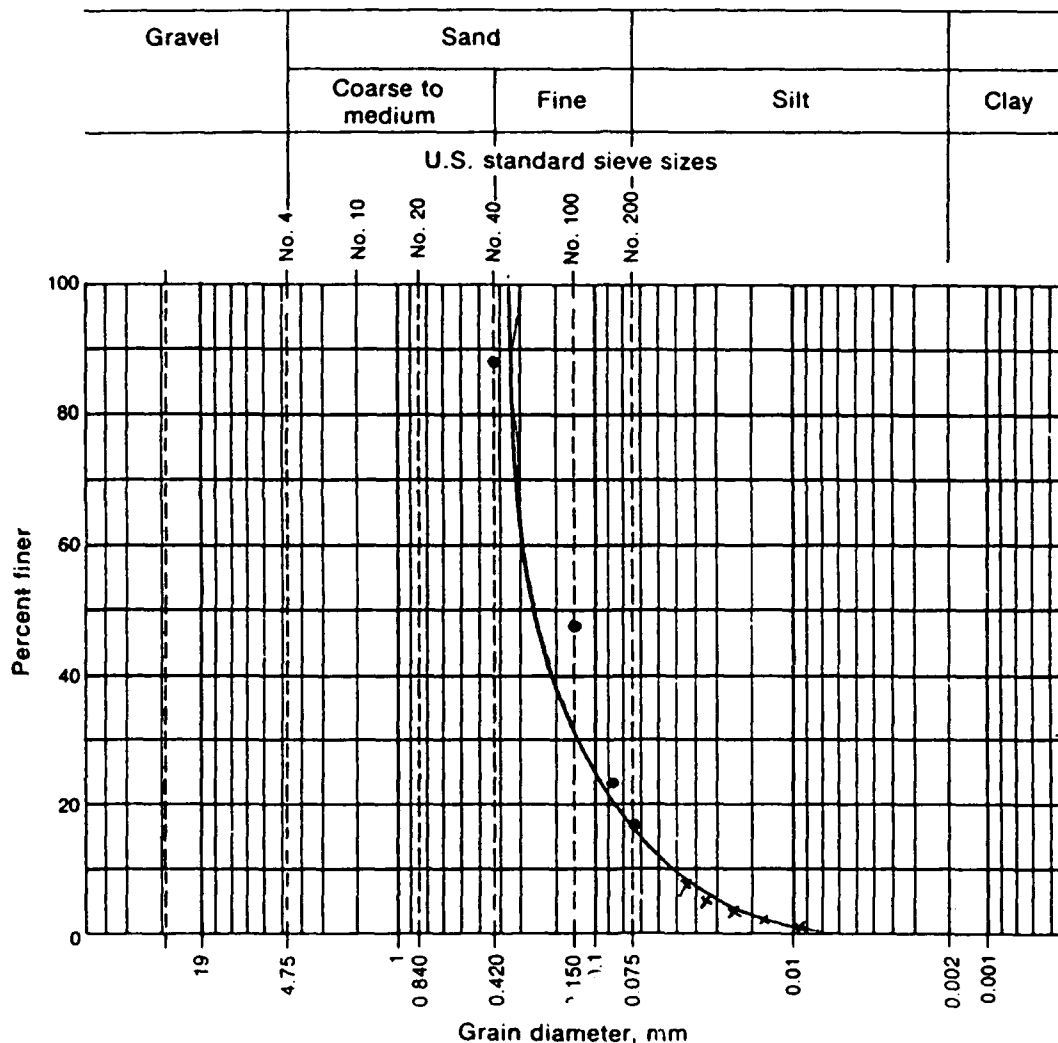
Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S7

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded sand with fines, cu = 6.0

Soil classification:

SP System Unified Soil Classification

Gravels = 0 % ; Sands = 83 % ; Silts+clays = 17 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project Caliente creek Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S8

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

*Soil Sample Size (ASTM D1140-54)*

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	924 gram

*Sieve analysis and grain shape*

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
7	2.83	66.0	7.14	92.86
30	0.594	511.0	55.30	37.56
40	0.425	150.0	16.23	21.33
100	0.149	178.5	19.31	2.02
170	0.088	13.5	1.46	0.56
200	0.075	1.0	0.108	0.452
pan	-	4.0	0.432	-0-

% passing =  $100 - \sum$  % retained.

# GRAIN SIZE DISTRIBUTION

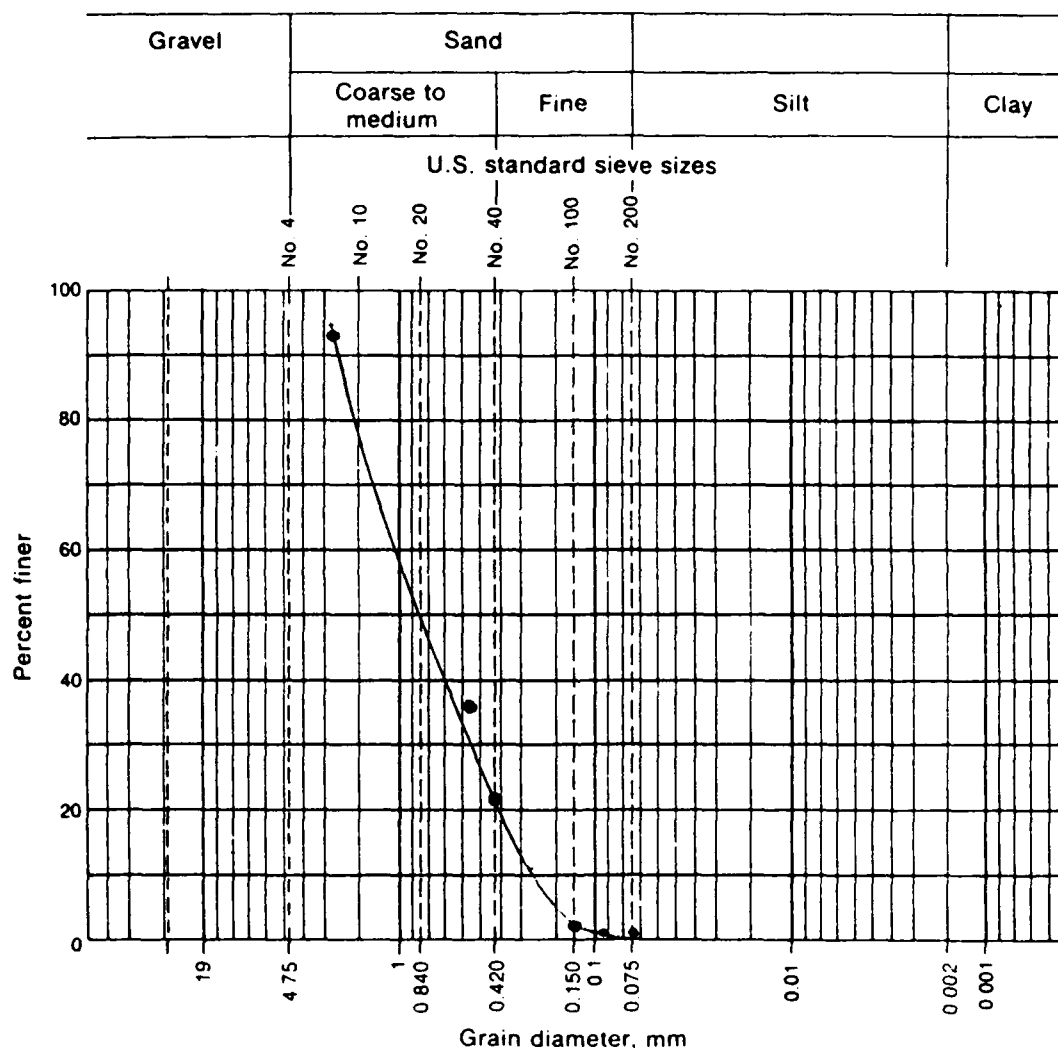
Data Sheet 6

Project CALIENTE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S8

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded clean sand,  $c_u = 5.09$

Soil classification:

SP System Unified Soil Classification

Gravels = 0 % ; Sands = 99.5 % ; Silts+clays = 0.5 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S9  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

*Soil Sample Size (ASTM D1140-54)*

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	1,074 gram

*Sieve analysis and grain shape*

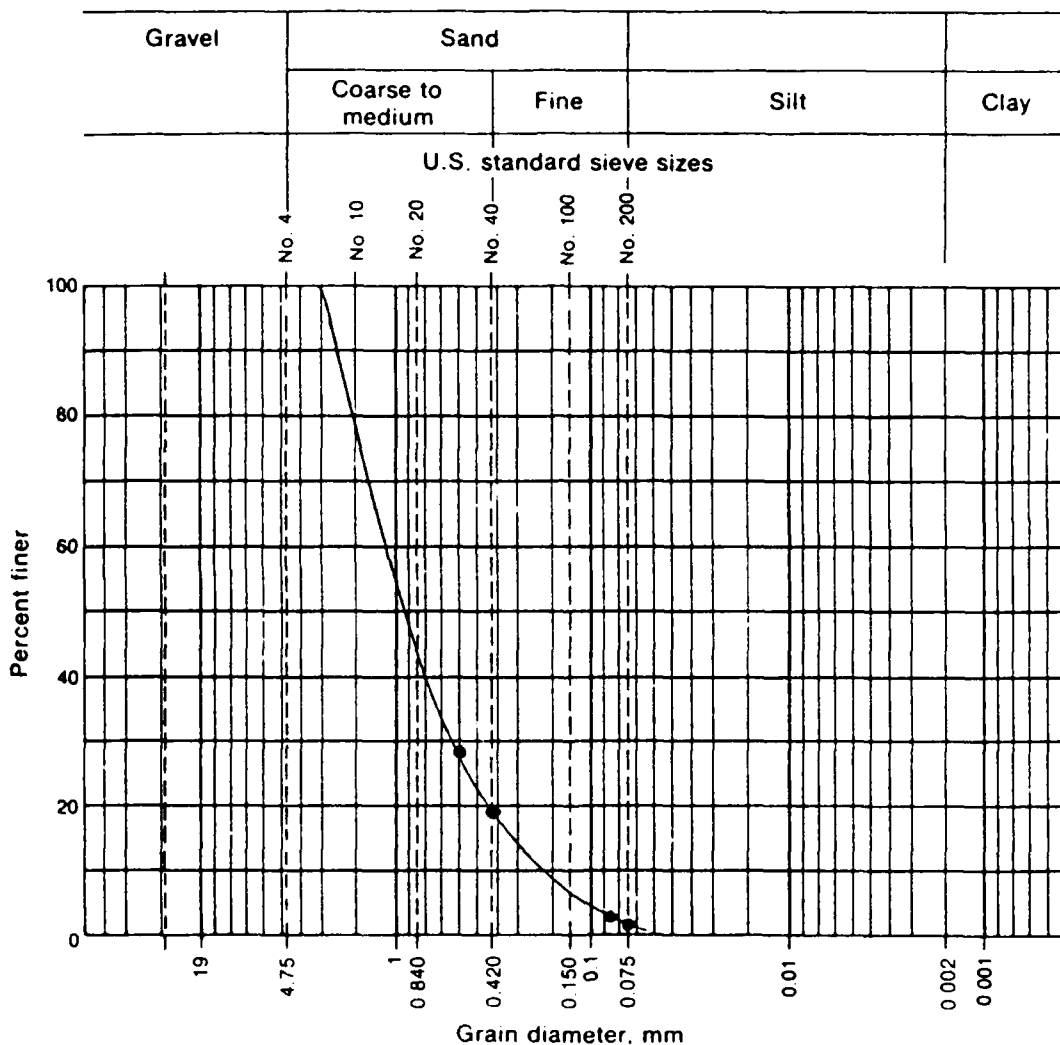
Sieve no.	Diam (mm)	Wt. retained	% retained	% passing
30	0.594	755.0	70.29	29.71
40	0.425	113.0	10.52	19.19
170	0.088	189.0	17.59	1.60
200	0.075	10.0	0.93	0.67
pan	-	7.0	0.65	-0-

$$\% \text{ passing} = 100 - \sum \% \text{ retained.}$$

# GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S9  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded clean sand,  $c_u = 6.0$

Soil classification:  
 (SW) - SP System Unified Soil Classification

Gravels = 0 % ; Sands = 99.3 % ; Silts+clays = 0.7 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S10

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

## Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	793 gram

## Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
30	0.594	251.50	31.71	68.29
40	0.425	84.50	10.65	57.64
100	0.149	267.00	33.66	23.98
170	0.088	89.50	11.28	12.70
200	0.075	29.50	3.72	8.98
Pan	-	71.0	8.95	-0-

% passing =  $100 - \sum$  % retained.



## Data Sheet 7

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Zero correction +4                      Meniscus correction +1

[illegible]

$$D = K\sqrt{L/\theta}$$

## GRAIN SIZE DISTRIBUTION

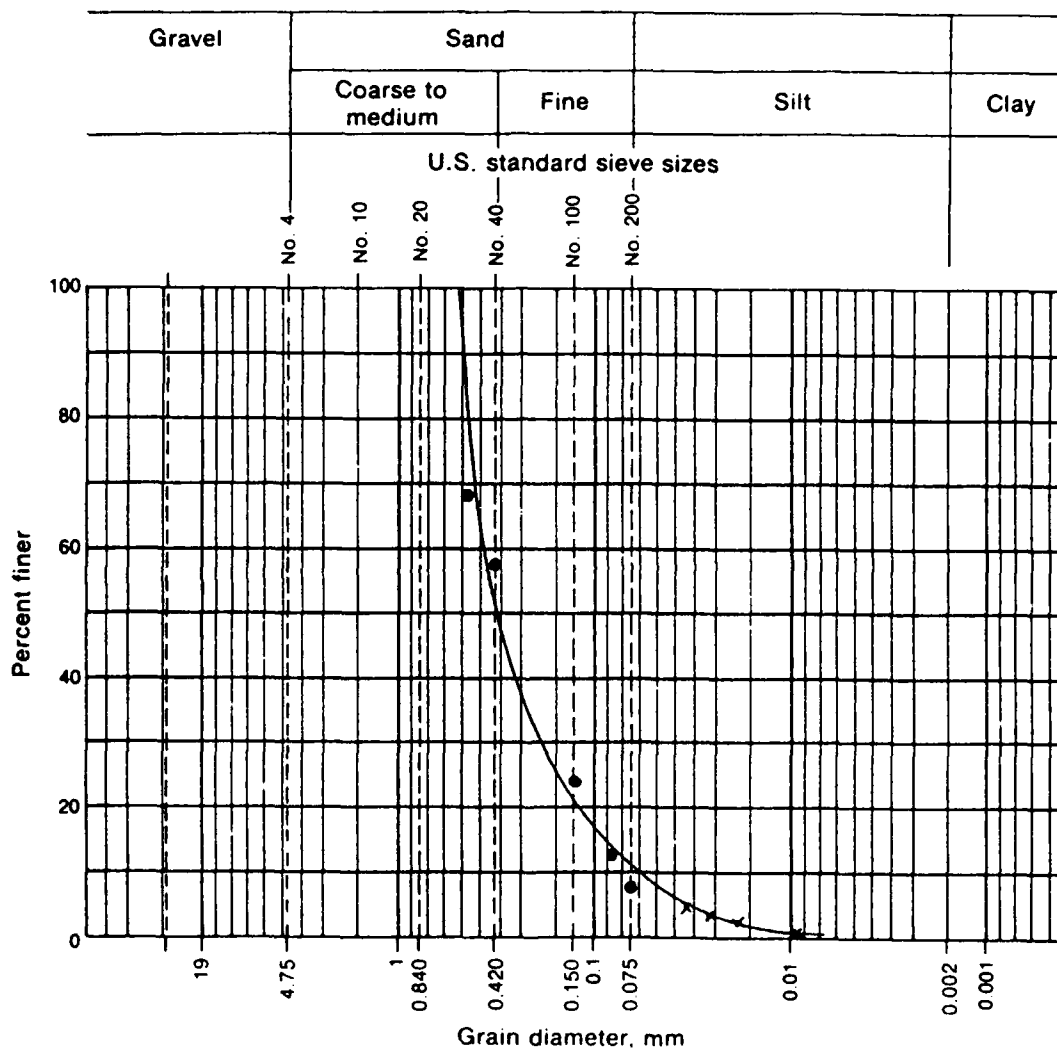
Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S10

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded sand with fines,  $c_u = 5.62$

Soil classification:

SP

System Unified Soil Classification

Gravels = 0 % ; Sands = 91 % ; Silts + clays = 9 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S11

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

*Soil Sample Size (ASTM D1140-54)*

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	1,151.50 gram

*Sieve analysis and grain shape*

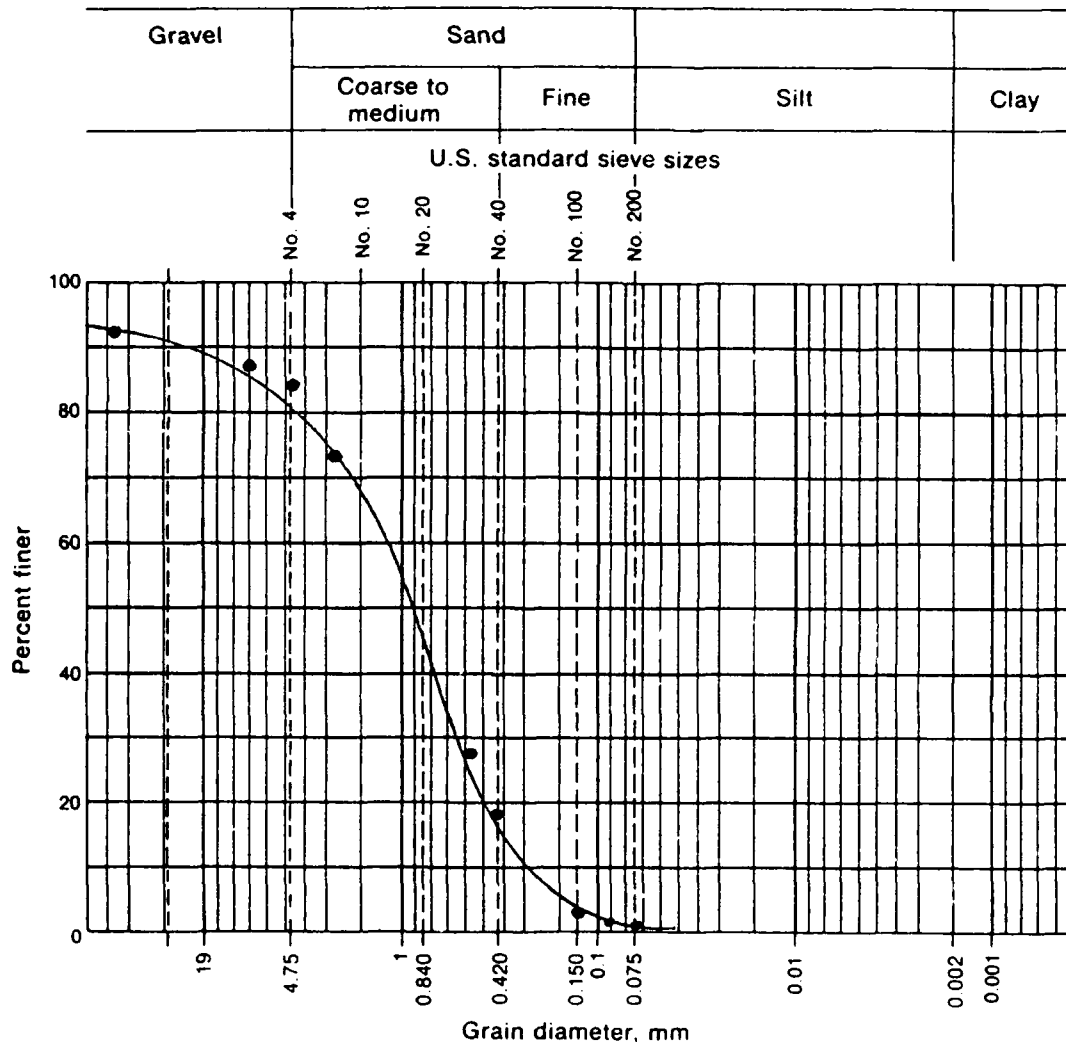
Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
-	12.50	97.0	8.42	91.58
-	6.30	38.0	3.30	88.28
4	4.75	34.0	2.95	85.33
7	2.83	140.0	12.15	73.18
30	0.594	516.50	44.85	28.33
40	0.425	107.0	9.29	19.04
100	0.149	207.0	17.97	1.07
170	0.088	10.0	0.86	0.22
200	0.075	1.0	0.08	0.13
pan	-	1.0	0.08	-0-

% passing =  $100 - \sum$  % retained.

# GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S11  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Well graded sand with some gravels  
cu = 5.86

Soil classification:

SW System Unified Soil Classification

Gravels = 19 % ; sands = 80.87 % ; Silts + Clays = 0.13 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S12

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

*Soil Sample Size (ASTM D1140-54)*

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	770.50 gram

*Sieve analysis and grain shape*

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
7	2.83	82.0	10.64	89.36
30	0.594	259.50	33.67	55.69
40	0.425	103.0	13.36	42.33
100	0.149	272.0	35.30	7.03
170	0.088	35.0	4.54	2.49
200	0.075	7.0	0.90	1.59
pan	-	12.0	1.55	-0-

$$\% \text{ passing} = 100 - \sum \% \text{ retained.}$$

## GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK

Job. No. \_\_\_\_\_

Location of Project \_\_\_\_\_

Boring No. \_\_\_\_\_

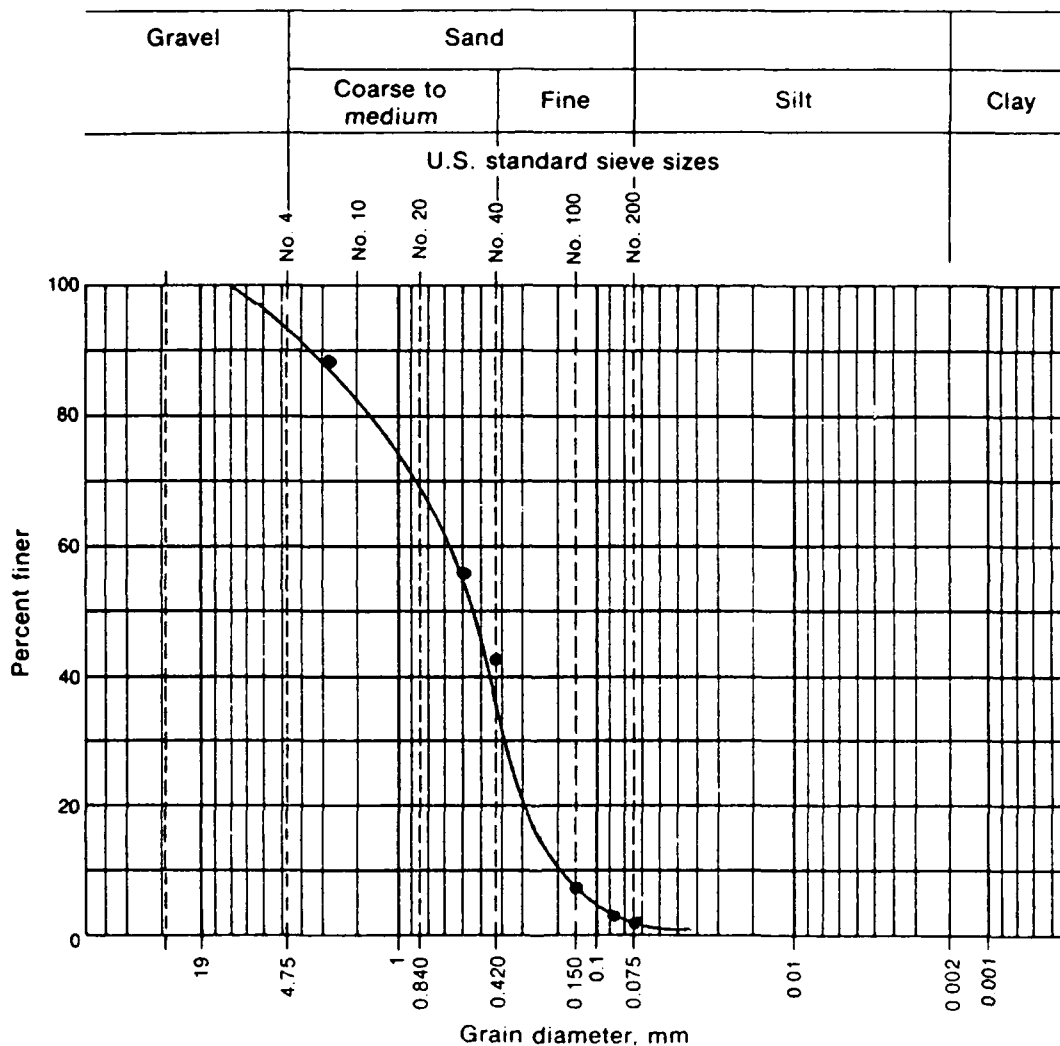
Sample No. S12

Description of Soil \_\_\_\_\_

Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_

Date of Testing \_\_\_\_\_

Visual soil description Poorly graded sand., cu = 3.57

Soil classification:

SP

System

Unified Soil Classification

Gravels = 5 % ; Sands = 93.50 % ; Silts+clays= 1.5 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S13

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

## Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	922.0 gram

## Sieve analysis and grain shape

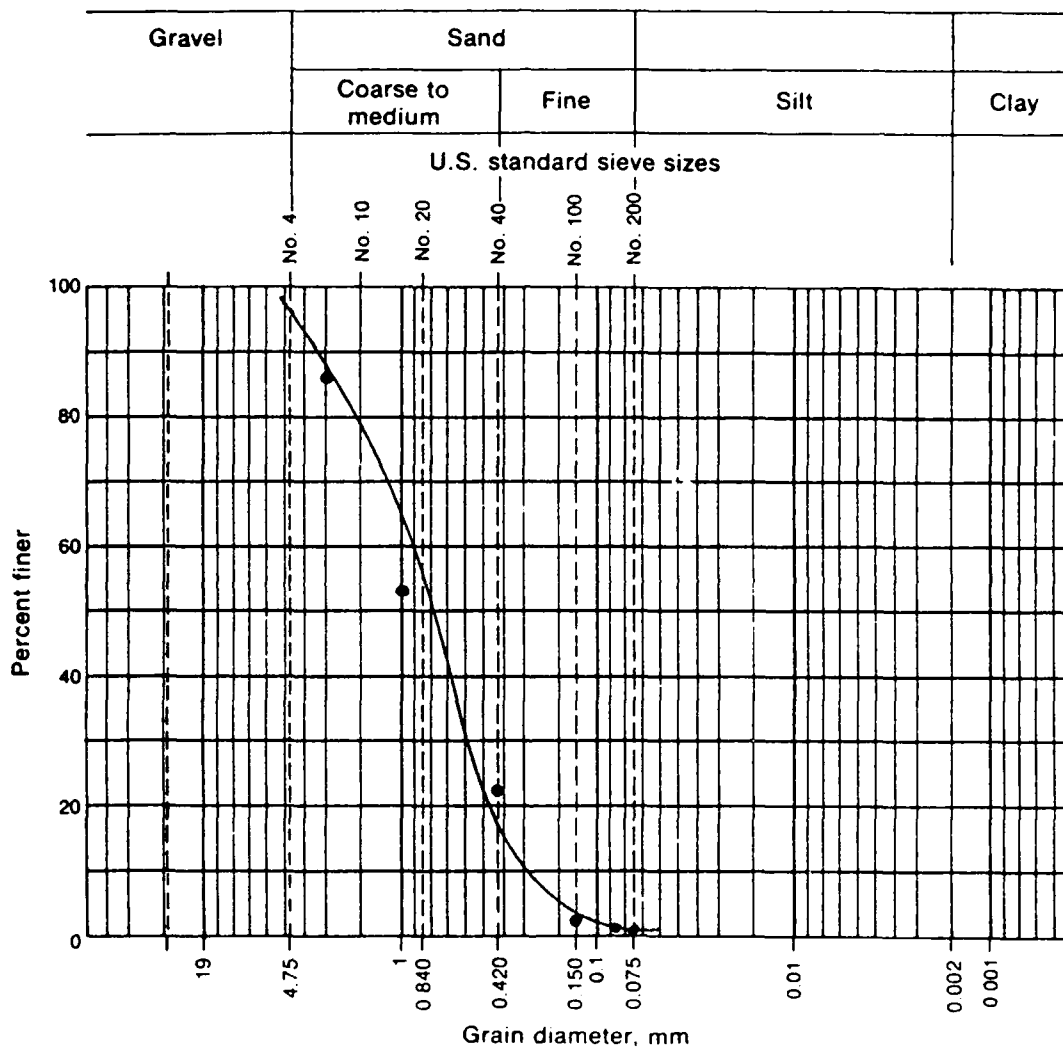
Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
7	2.83	130.0	14.09	85.91
18	1.00	294.0	31.94	53.97
40	0.425	299.0	32.42	21.55
100	0.149	183.0	19.84	1.71
170	0.088	11.0	1.19	0.52
200	0.075	1.0	0.10	0.42
pan	-	4.0	0.43	-0-

$$\% \text{ passing} = 100 - \sum \% \text{ retained.}$$

# GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S13  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded sand with little fines, cu = 4.28

Soil classification:

Sp-(SW) System Unified Soil Classification

Gravels = 7 % ; Sands = 92.5 % ; Silts+clays = 0.5 %



## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S14

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	886.50 gram

## Sieve analysis and grain shape

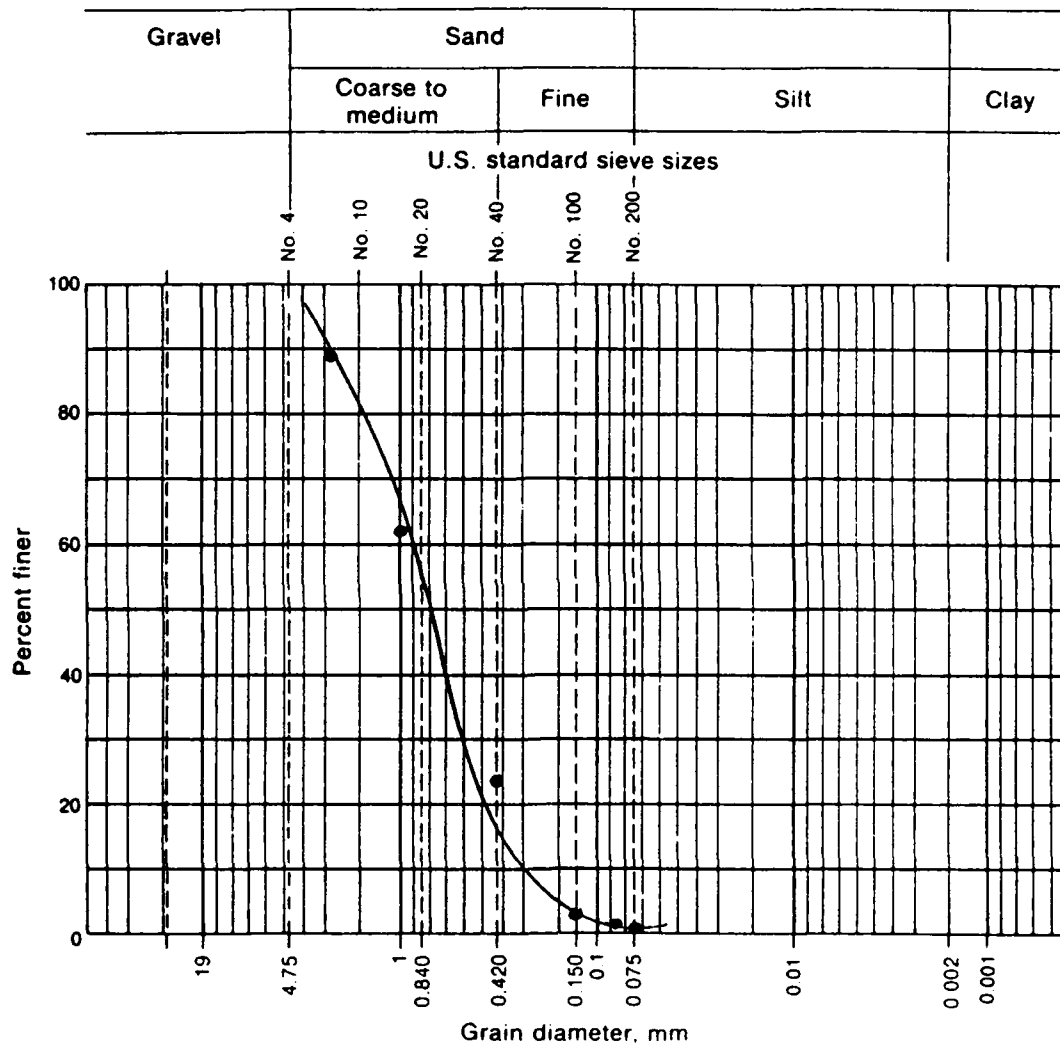
Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
7	2.83	89.5	10.09	89.90
18	1.00	240.0	27.07	62.83
40	0.425	341.0	38.46	24.37
100	0.149	203.0	22.89	1.48
170	0.088	10.0	1.128	0.361
200	0.075	1.0	0.112	0.24
pan	-	2.0	0.22	-.0-

% passing =  $100 - \sum$  % retained.

# GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S14  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded sand,  $c_u = 3.92$

Soil classification:  
SP System Unified Soil Classification

Gravels = 4 % ; Sands = 95.75 % ; Silts+clays = 0.25 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S15

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

## Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	1,027.5 gram

## Sieve analysis and grain shape

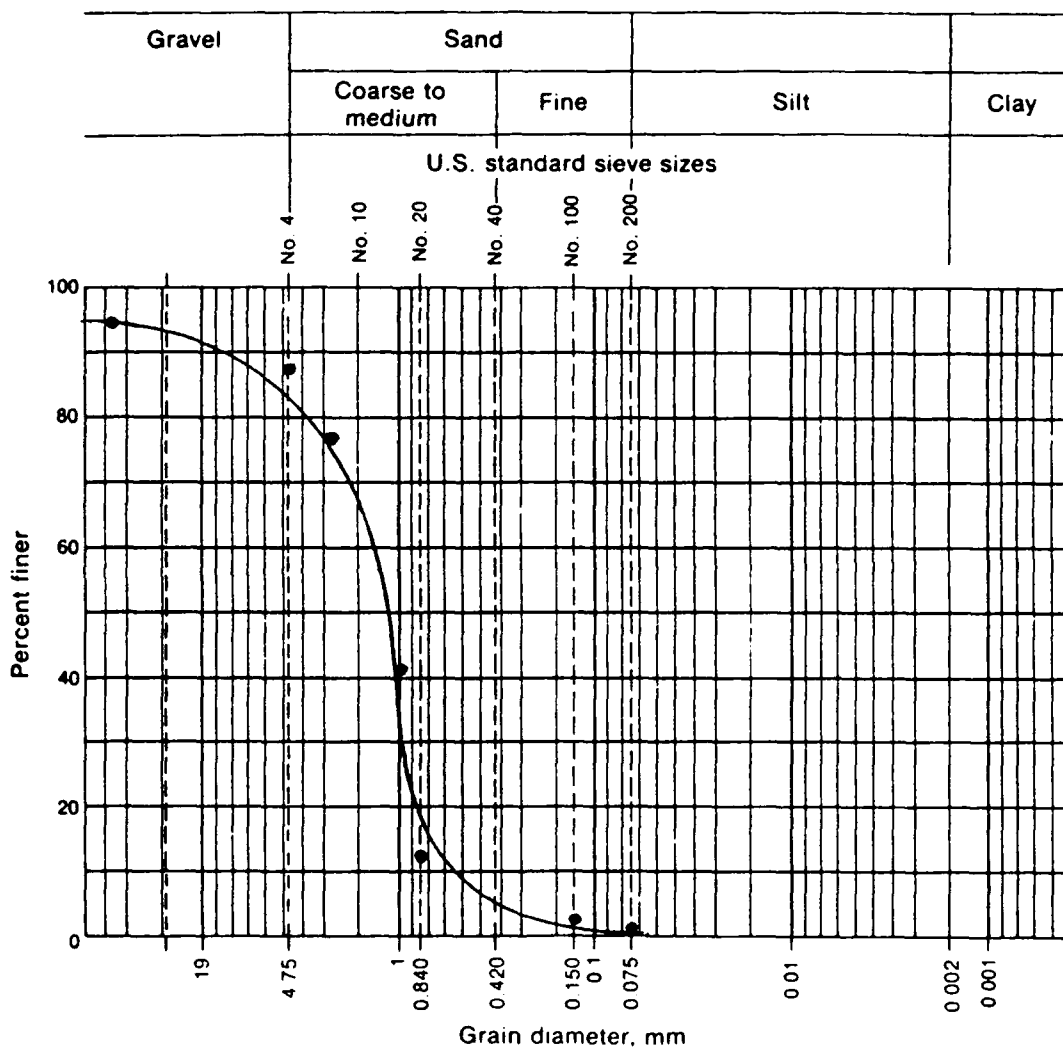
Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
-	12.50	43.0	4.18	95.82
4	4.75	89.0	8.66	87.16
7	2.83	99.0	9.63	77.53
18	1.00	384.50	37.42	40.11
40	0.42	283.50	27.59	12.52
100	0.149	107.00	10.41	2.11
200	0.075	13.5	1.31	0.80
pan	-	8.0	0.77	-0-

% passing =  $100 - \sum$  % retained.

# GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK Job. No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S15  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By. \_\_\_\_\_ Date of Testing \_\_\_\_\_



Visual soil description Poorly graded sands with little gravels  
cu = 2.13

Soil classification:

SP

System Unified Soil Classification

Gravels = 12.5 % ; Sands = 86.5 % ; Silts+clays = 1 %

## GRAIN SIZE ANALYSIS-MECHANICAL

Data Sheet 5

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S16

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of testing \_\_\_\_\_

Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, $W_s$	1,673.50 gram

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing
-	19.0	306.5	18.31	81.69
-	12.50	127.50	7.61	74.08
-	6.3	216.50	12.93	61.15
4	4.75	74.0	4.42	56.73
7	2.83	149.0	8.90	47.83
18	1.0	362.0	21.63	26.20
40	0.42	234.50	14.01	12.19
100	0.149	152.0	9.08	3.11
200	0.075	34.5	2.06	1.05
pan	-	17.0	1.015	-0-

% passing =  $100 - \sum$  % retained.

# GRAIN SIZE DISTRIBUTION

Data Sheet 6

Project CALIENTE CREEK

Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_

Boring No. \_\_\_\_\_

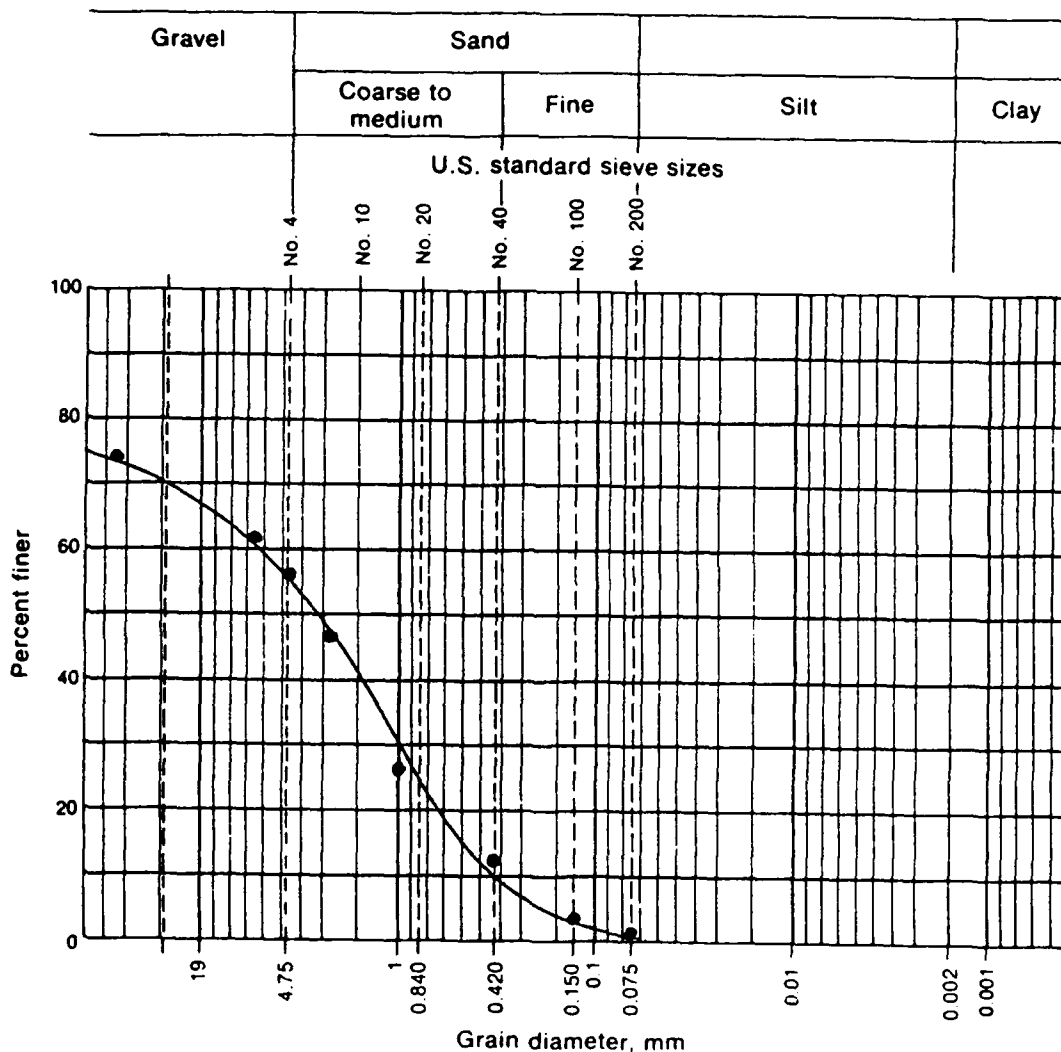
Sample No. S16

Description of Soil \_\_\_\_\_

Depth of Sample \_\_\_\_\_

Tested By. \_\_\_\_\_

Date of Testing \_\_\_\_\_



Visual soil description Well graded sand, cu = 14.5

Soil classification:

SW

System

Unified Soil Classification

Gravels = 43.25 % ; Sands = 55.75 % ; Silts+clays = 1.0 %

Table 3.5 Unified Soil Classification

Field Identification Procedures (Excluding particles larger than 75 $\mu$ m and basing fractions on estimated weight)			Group Symbols	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of material is larger than 75 $\mu$ m sieve size (The 75 $\mu$ m sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)				
Fine-grained soils More than half of material is smaller than 75 $\mu$ m sieve size	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentage of sand and gravel; maximum size; angularity; surface condition; and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{D_{30}^3}{D_{10} \times D_{60}}$ Between 1 and 3
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW
		Nonplastic fines (for identification procedures see <i>ML</i> below)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or <i>PI</i> less than 4
		Plastic fines (for identification procedures, see <i>CL</i> below)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with <i>PI</i> greater than 7
Identification Procedures on Fraction Smaller than 380 $\mu$ m Sieve Size	Sands with fines (appreciable amount of fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	SW	Well graded sands, gravelly sands, little or no fines	Example: Silty sand, gravelly, about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM)	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{D_{30}^3}{D_{10} \times D_{60}}$ Between 1 and 3
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW
		Nonplastic fines (for identification procedures, see <i>ML</i> below)	SM	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or <i>PI</i> less than 5
		Plastic fines (for identification procedures, see <i>CL</i> below)	SC	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits above "A" line with <i>PI</i> greater than 7
Highly Organic Soils	Silt and clay greater than 50 $\mu$ m sieve size	Dry Strength (crushing character-istics)				
		Quickness (reaction to shaking)				
		Toughness (consistency near plastic limit)				
		None to slight	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition; odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses	
		Medium to high	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions	
		Slight to medium	OL	Organic silts and organic silts of low plasticity	Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; locas; (ML)	

From Warner, 1917.  
a. Boundary classification. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.  
b. All sieve sizes on this chart are U.S. standard.

These procedures are to be performed on the minus 380  $\mu$ m sieve size particles.  
Dilatancy (Reaction to shaking):  
After removing particles larger than 380  $\mu$ m sieve size, prepare a pat of moist soil with a volume of about 8000 mm<sup>3</sup>. Add enough water if necessary to make the soil soft but not sticky.  
Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat, which changes to a lively consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.  
Very fine clean sands give the quickest and most distinct reaction, whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Field Identification Procedure for Fine Grained Soils or Fractions  
For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.  
Toughness (Consistency near plastic limit):  
After removing particles larger than the 380  $\mu$ m sieve size, a specimen of soil about 12 mm cube in size is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3 mm diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.  
Alter the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.  
The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.  
Highly organic clays have a very weak and spongy feel at the plastic limit.

SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project CALIENTE CREEK

Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S1

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	403.99			
Temperature, °C	19 °C			
Wt. flask + water <sup>b</sup> = $W_{bw}$	357.41			
Evap. dish no.	--			
Wt. evap. dish + dry soil	150.81			
Wt. of evap. dish	76.53			
Wt. of dry soil = $W_s$	74.28			
$W_w = W_s + W_{bw} - W_{bws}$	27.70			
$G_s = \alpha W_s / W_w$	2.682			

<sup>a</sup>Indicate vacuum or aspirator for air removal.<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$  or value from calibration curve at  $T$  of  $W_{bws}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.682



SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S2

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{dws}$	435.35			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{dw}$	366.88			
Evap. dish no.	-			
Wt. evap. dish + dry soil	216.70			
Wt. of evap. dish	109.40			
Wt. of dry soil = $W_s$	107.30			
$W_w = W_s + W_{dw} - W_{dws}$	38.83			
$G_s = \alpha W_s / W_w$	2.76			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{dw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{dws}$  or value from calibration curve at  $T$  of  $W_{dws}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.76

# **SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )**

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S3  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{b+w}$	411.38			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{b+w}$	348.02			
Evap. dish no.	-			
Wt. evap. dish + dry soil	285.21			
Wt. of evap. dish	184.96			
Wt. of dry soil = $W_s$	100.25			
$W_w = W_s + W_{b+w} - W_{b+w}$	36.89			
$G_s = \alpha W_s / W_w$	2.717			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{b+w}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{b+w}$  or value from calibration curve at  $T$  of  $W_{b+w}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.717

SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S4

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{buc}$	463.56			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	423.64			
Evap. dish no.	--			
Wt. evap. dish + dry soil	167.89			
Wt. of evap. dish	104.57			
Wt. of dry soil = $W_s$	63.32			
$W_w = W_s + W_{bw} - W_{buc}$	23.40			
$G_s = \alpha W_s / W_w$	2.705			

<sup>a</sup>Indicate vacuum or aspirator for air removal.<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{buc}$  or value from calibration curve at T of  $W_{buc}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.705

SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S5

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	398.75			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	366.56			
Evap. dish no.	-			
Wt. evap. dish + dry soil	127.54			
Wt. of evap. dish	76.44			
Wt. of dry soil = $W_s$	51.10			
$W_w = W_s + W_{bw} - W_{bws}$	18.91			
$G_s = \alpha W_s / W_w$	2.702			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$  or value from calibration curve at  $T$  of  $W_{bws}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.702

SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S6

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	395.70			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	348.23			
Evap. dish no.	-			
Wt. evap. dish + dry soil	144.77			
Wt. of evap. dish	69.16			
Wt. of dry soil = $W_s$	75.61			
$W_w = W_s + W_{bw} - W_{bws}$	28.14			
$G_s = \alpha W_s / W_w$	2.687			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$  or value from calibration curve at  $T$  of  $W_{bws}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.687

**SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )**

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S7  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bwy}$	381.56			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	348.23			
Evap. dish no.	-			
Wt. evap. dish + dry soil	167.39			
Wt. of evap. dish	114.87			
Wt. of dry soil = $W_s$	52.52			
$W_{sc} = W_s + W_{bwc} - W_{bws}$	19.19			
$G_s = \alpha W_s / W_{sc}$	2.737			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bwy}$  or value from calibration curve at  $T$  of  $W_{bwy}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.737

SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S8

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{dwt}$	405.55			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{dw}$	366.61			
Evap. dish no.	--			
Wt. evap. dish + dry soil	138.32			
Wt. of evap. dish	76.35			
Wt. of dry soil = $W_s$	61.97			
$W_w = W_s + W_{dw} - W_{dwt}$	23.03			
$G_s = \alpha W_s / W_w$	2.69			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{dw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{dwt}$ , or value from calibration curve at  $T$  of  $W_{dwt}$ .

Remarks \_\_\_\_\_

\_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.69

# **SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )**

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S9

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	396.82			
Temperature, °C	19.0			
Wt. flask + water <sup>b</sup> = $W_{bw}$	348.13			
Evap. dish no.	--			
Wt. evap. dish + dry soil	146.66			
Wt. of evap. dish	69.18			
Wt. of dry soil = $W_s$	77.48			
$W_w = W_s + W_{bw} - W_{bws}$	28.79			
$G_s = \alpha W_s / W_w$	2.69			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$  or value from calibration curve at  $T$  of  $W_{bws}$

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.69



**SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )**

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S10  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	386.10			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	346.94			
Evap. dish no.	--			
Wt. evap. dish + dry soil	138.0			
Wt. of evap. dish	76.30			
Wt. of dry soil = $W_s$	61.70			
$W_w = W_s + W_{bw} - W_{bws}$	22.54			
$G_s = \alpha W_s / W_w$	2.7373			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$  or value from calibration curve at  $T$  of  $W_{bws}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.737

# **SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )**

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No S11  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	390.29			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	346.45			
Evap. dish no.	--			
Wt. evap. dish + dry soil	146.57			
Wt. of evap. dish	76.88			
Wt. of dry soil = $W_s$	69.69			
$W_w = W_s + W_{bw} - W_{bws}$	25.85			
$G_s = \alpha W_s / W_w$	2.695			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$ , or value from calibration curve at  $T$  of  $W_{bws}$

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.695

SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project CALINETE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S12

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	389.30			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	348.31			
Evap. dish no.	--			
Wt. evap. dish + dry soil	250.26			
Wt. of evap. dish	184.93			
Wt. of dry soil = $W_s$	65.33			
$W_w = W_s + W_{bw} - W_{bws}$	24.34			
$G_s = \alpha W_s / W_w$	2.684			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$ , or value from calibration curve at  $T$  of  $W_{bws}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.584

SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project Caliente Creek Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S13

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	385.83			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	346.73			
Evap. dish no.	--			
Wt. evap. dish + dry soil	247.05			
Wt. of evap. dish	185.08			
Wt. of dry soil = $W_s$	61.97			
$W_w = W_s + W_{bw} - W_{bws}$	22.87			
$G_s = \alpha W_s / W_w$	2.709			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$  or value from calibration curve at  $T$  of  $W_{bws}$

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.709

**SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )**

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S14

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	397.34			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{bw}$	346.87			
Evap. dish no.	--			
Wt. evap. dish + dry soil	190.22			
Wt. of evap. dish	109.44			
Wt. of dry soil = $W_s$	80.78			
$W_w = W_s + W_{bw} - W_{bws}$	30.31			
$G_s = \alpha W_s / W_w$	2.665			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$  or value from calibration curve at  $T$  of  $W_{bws}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.665

**SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )**

Data Sheet 8

Project CALIENTE CREEK Job No. \_\_\_\_\_  
 Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S15  
 Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_  
 Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{bws}$	414.94			
Temperature, °C	20.50			
Wt. flask + water <sup>b</sup> = $W_{bw}$	365.65			
Evap. dish no.	--			
Wt. evap. dish + dry soil	153.38			
Wt. of evap. dish	76.80			
Wt. of dry soil = $W_s$	76.58			
$W_{sc} = W_s + W_{bw} - W_{bws}$	27.29			
$G_s = \alpha W_s / W_{sc}$	2.806			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{bw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{bws}$  or value from calibration curve at  $T$  of  $W_{bws}$ .

Remarks \_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.806

SPECIFIC GRAVITY OF SOIL SOLIDS ( $G_s$ )

Data Sheet 8

Project Calente Creek Job No. \_\_\_\_\_

Location of Project \_\_\_\_\_ Boring No. \_\_\_\_\_ Sample No. S16

Description of Soil \_\_\_\_\_ Depth of Sample \_\_\_\_\_

Tested By \_\_\_\_\_ Date of Testing \_\_\_\_\_

Test no.	1			
Vol. of flask at 20°C	250 ml			
Method of air removal <sup>a</sup>	asp			
Wt. flask + water + soil = $W_{dwt}$	403.16			
Temperature, °C	20.5			
Wt. flask + water <sup>b</sup> = $W_{dw}$	365.65			
Evap. dish no.	--			
Wt. evap. dish + dry soil	135.03			
Wt. of evap. dish	76.48			
Wt. of dry soil = $W_s$	58.55			
$W_w = W_s + W_{dw} - W_{dwt}$	21.04			
$G_s = \alpha W_s / W_w$	2.782			

<sup>a</sup>Indicate vacuum or aspirator for air removal.

<sup>b</sup> $W_{dw}$  is the weight of the flask filled with water at same temp.  $\pm 1^\circ\text{C}$  as for  $W_{dwt}$  or value from calibration curve at  $T$  of  $W_{dwt}$ .

Remarks \_\_\_\_\_

\_\_\_\_\_

Average specific gravity of soil solids ( $G_s$ ) = 2.782

Untitled Data #1

Fri, Oct 27, 1989

	Oven dry	Dry at 550 F	organic	Organic, %
1	44.155	43.877	0.278	0.630
2	56.641	56.165	0.477	0.841
3	45.227	44.932	0.295	0.652
4	43.248	42.968	0.280	0.647
5	44.589	43.944	0.645	1.446
6	58.830	58.583	0.248	0.421
7	26.005	25.511	0.494	1.900
8	49.242	49.023	0.219	0.444
9	50.205	50.004	0.202	0.402
10	42.658	42.278	0.380	0.891
11	50.844	50.622	0.222	0.436
12	51.171	50.858	0.313	0.612
13	57.410	57.067	0.343	0.598
14	61.170	60.933	0.237	0.388
15	52.486	52.260	0.226	0.430
16	66.783	66.363	0.421	0.630

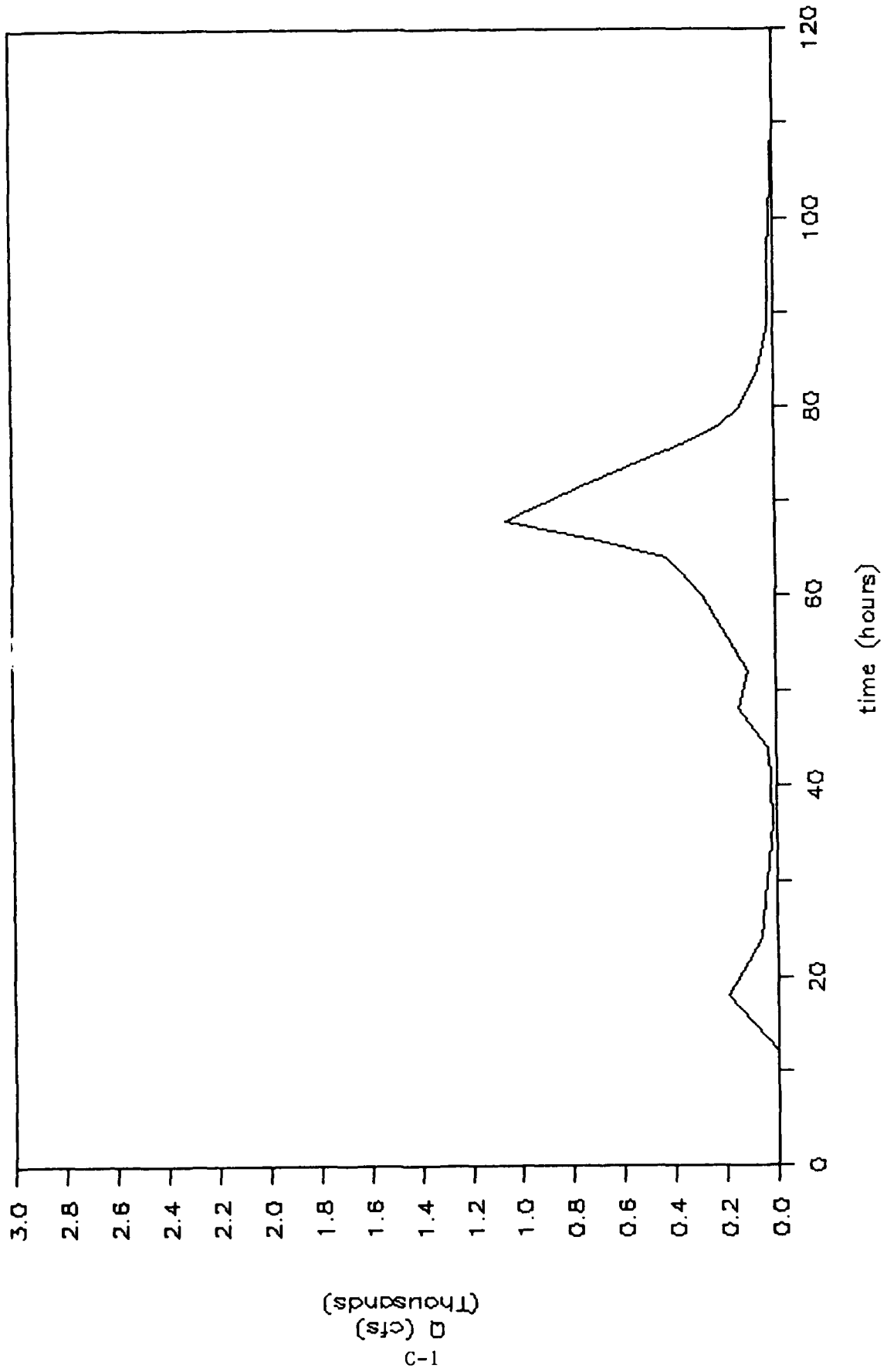


## **APPENDIX C**

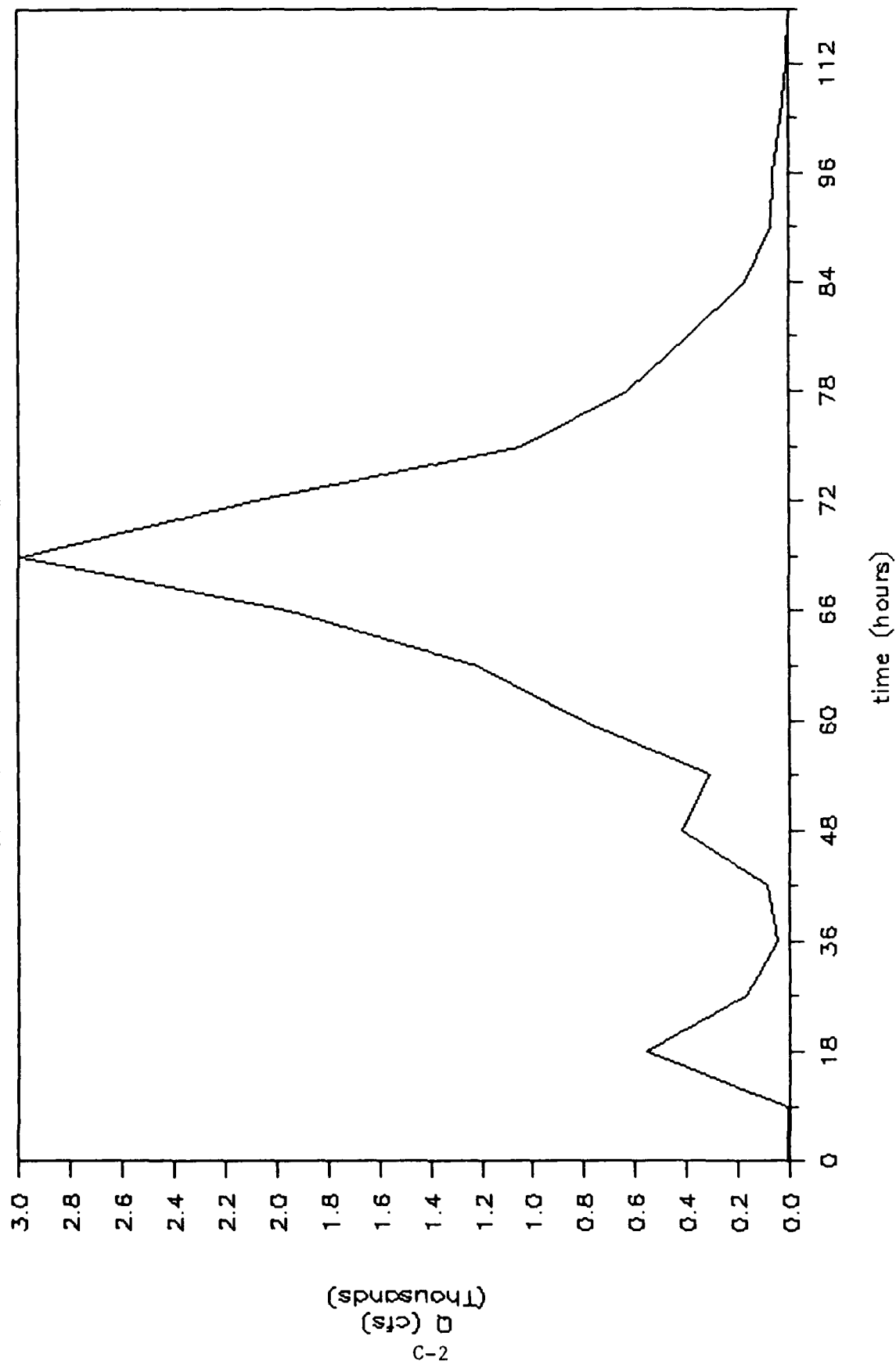
### **Synthesized Single Event Flood Hydrographs**

# CALIENTE CREEK

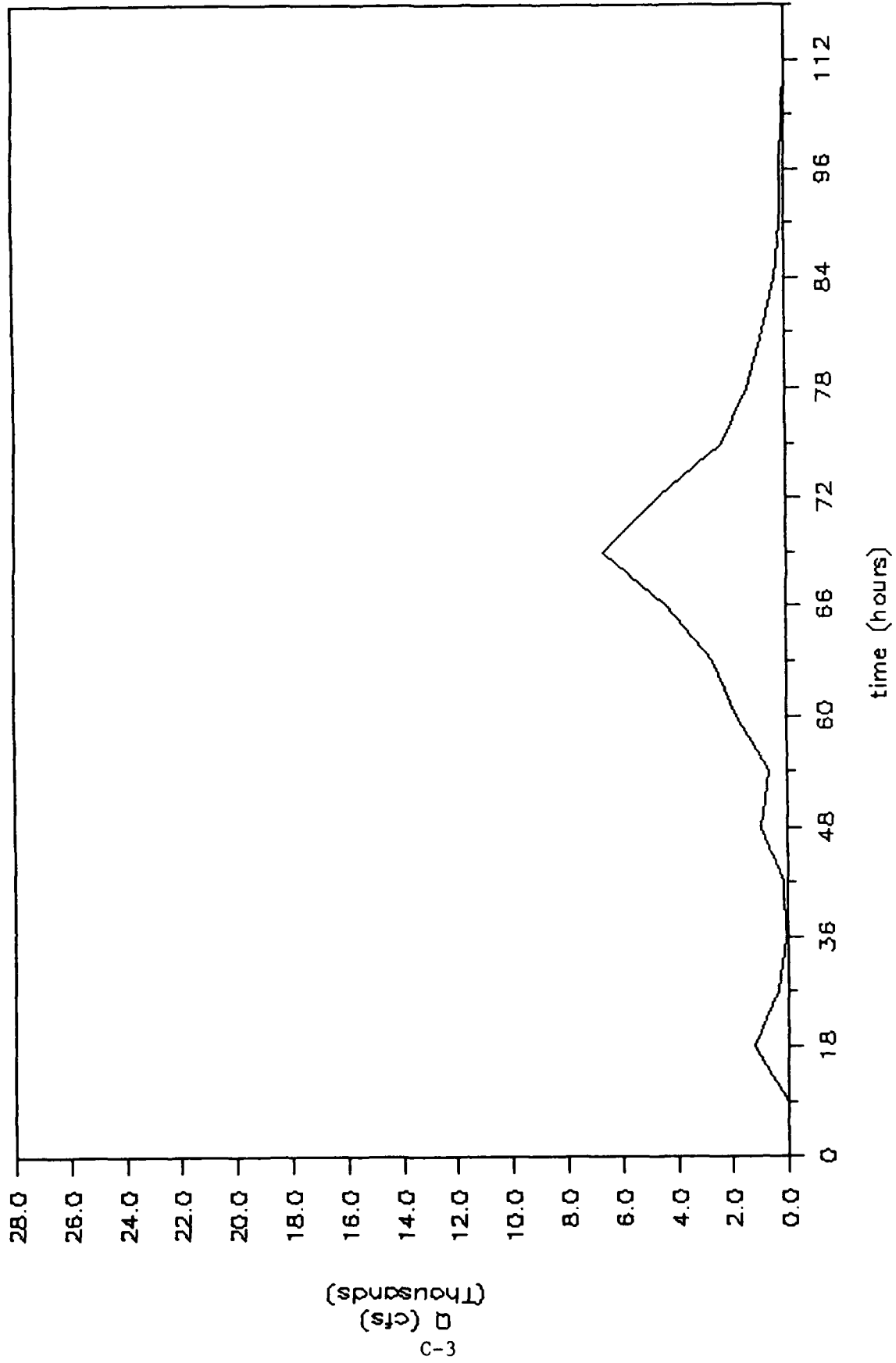
## 5-YR HYDROGRAPH AT SIVERT DAM



# CALIENTE CREEK 10-YR HYDROGRAPH AT SIVERT DAM

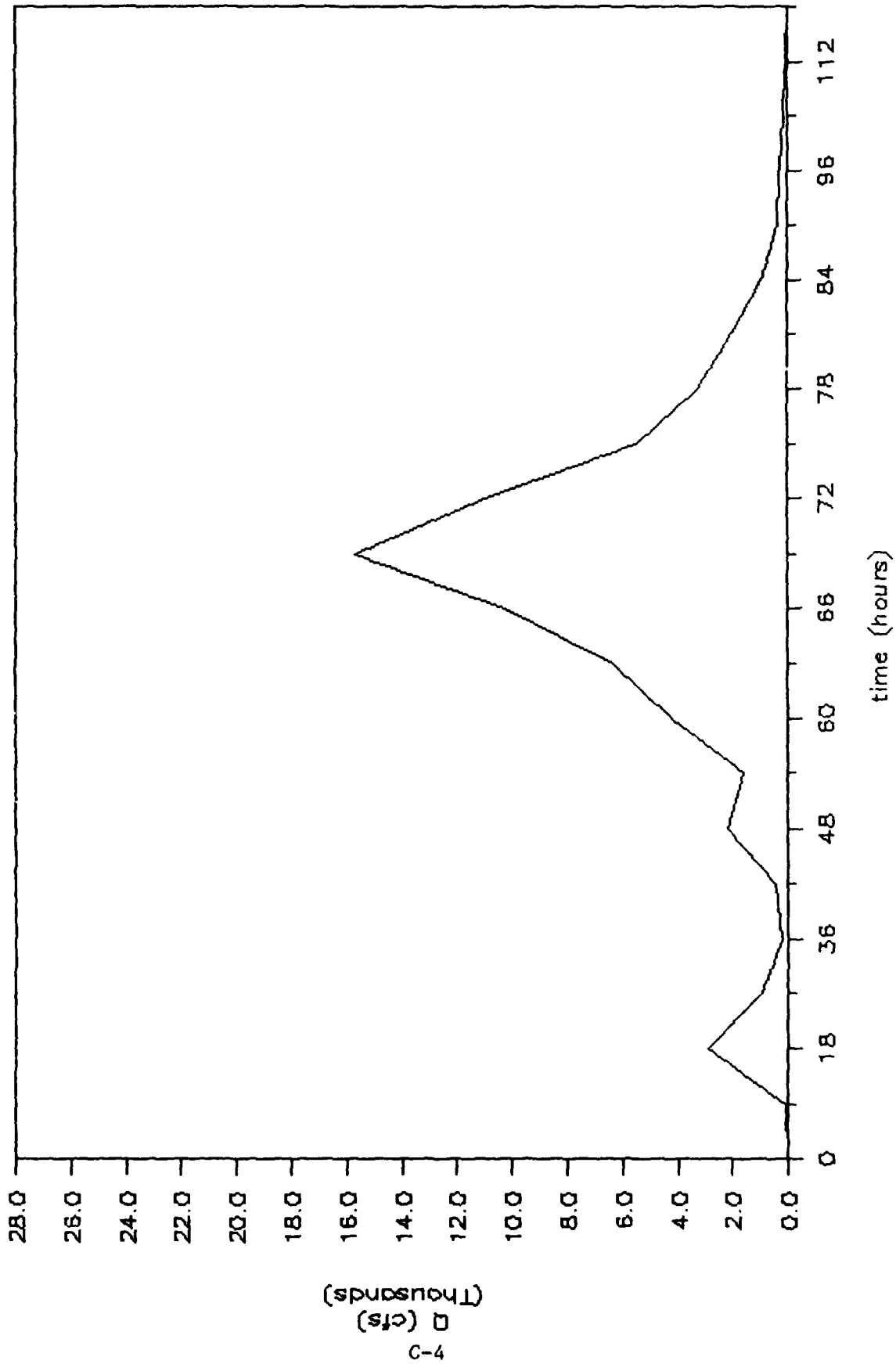


CALIENTE CREEK  
20-YR HYDROGRAPH AT SIVERT DAM

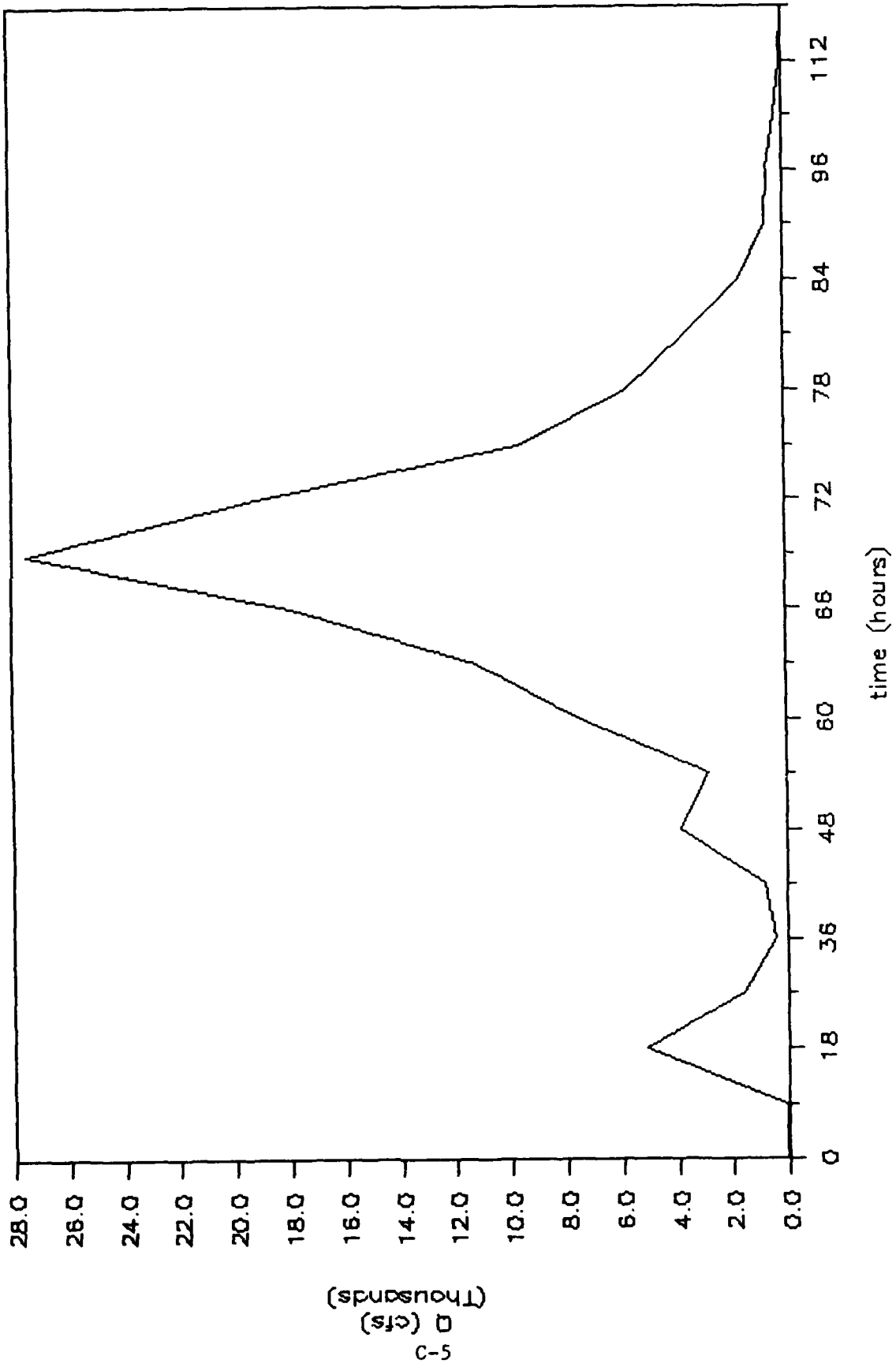


# CALIENTE CREEK

50-YR HYDROGRAPH AT SIVERT DAM

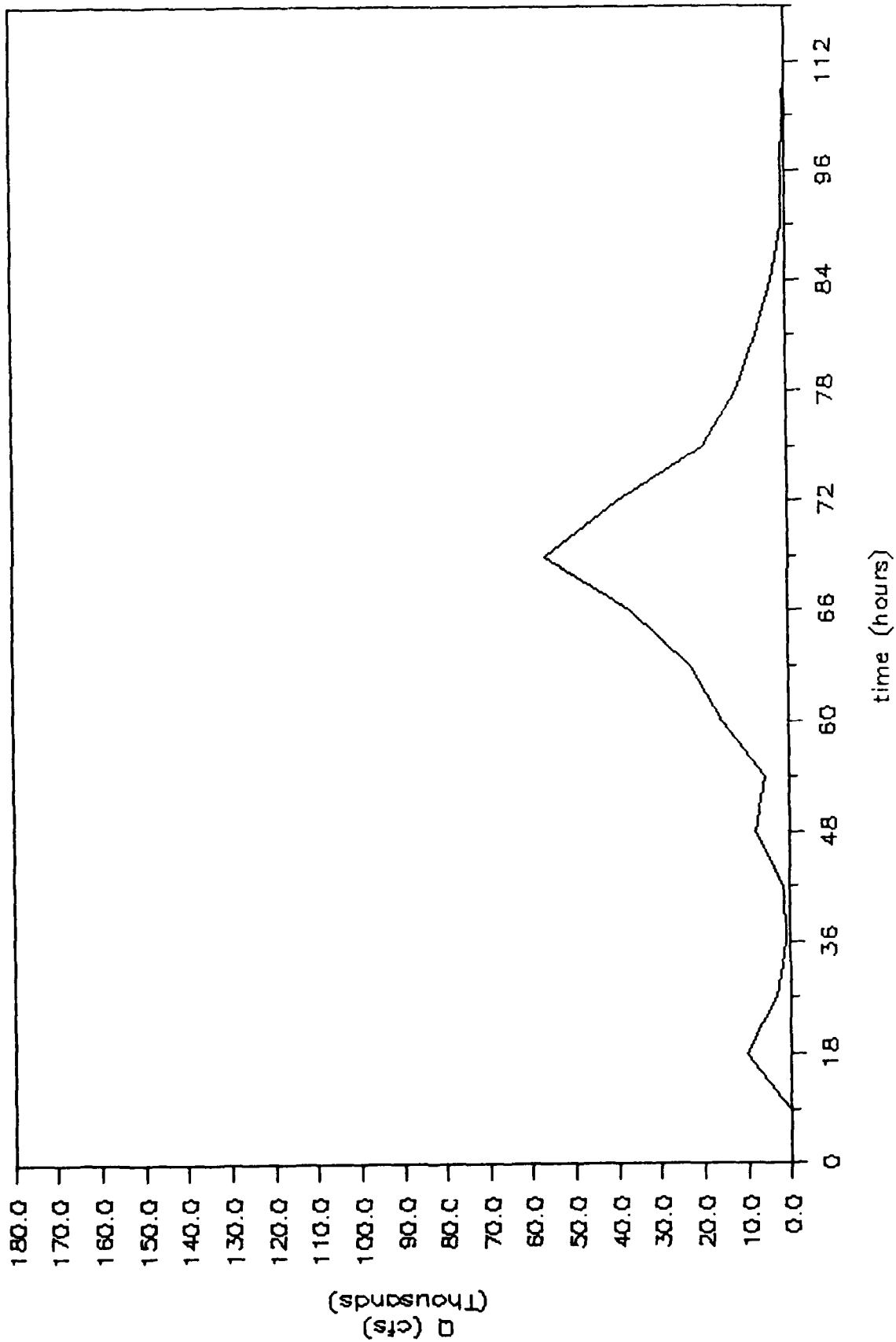


CALIENTE CREEK  
100-YR HYDROGRAPH AT SIVERT DAM



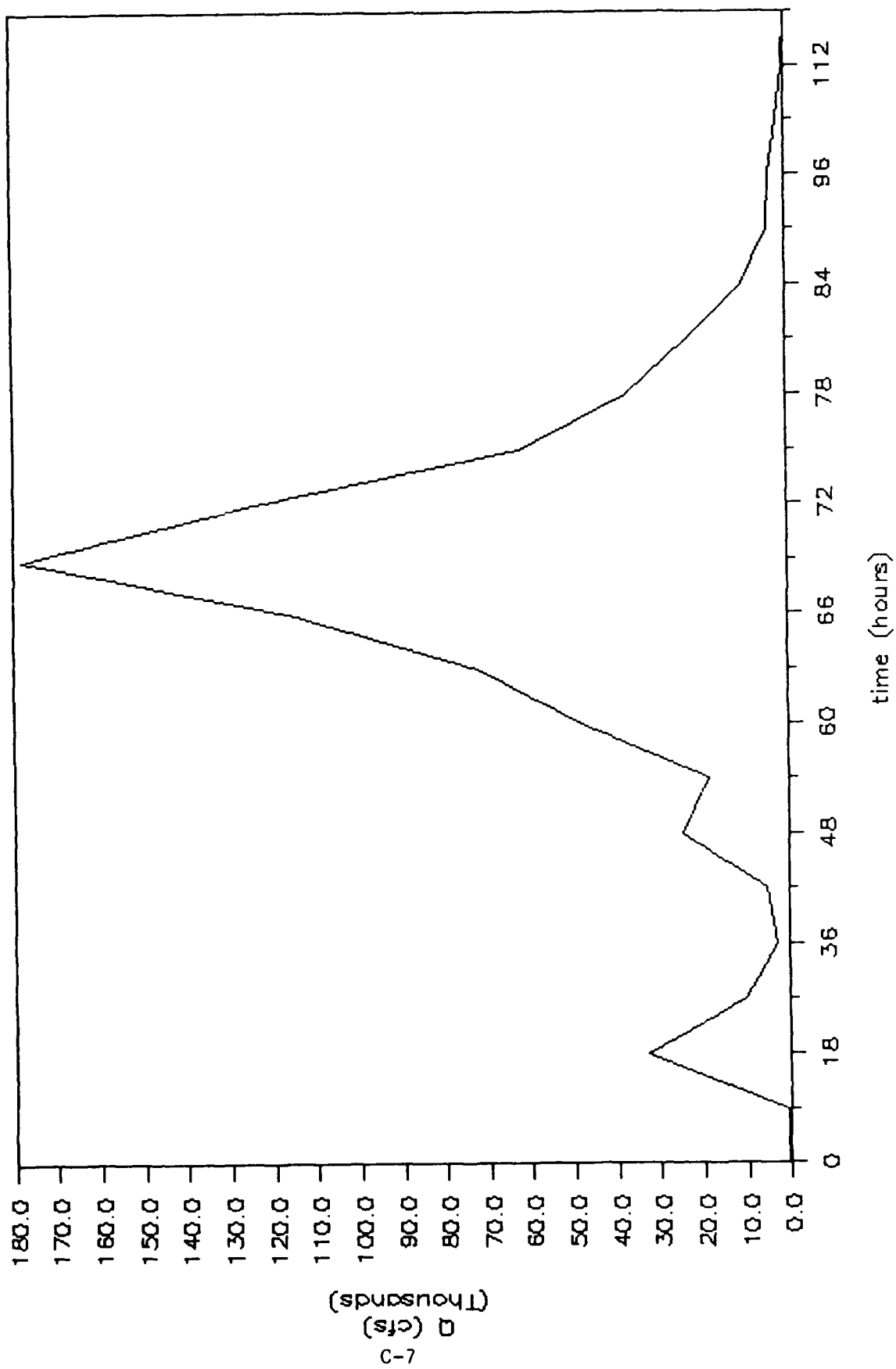
# CALIENTE CREEK

## SPF HYDROGRAPH AT SIVERT DAM



# CALIENTE CREEK

PMF HYDROGRAPH AT SIVERT DAM

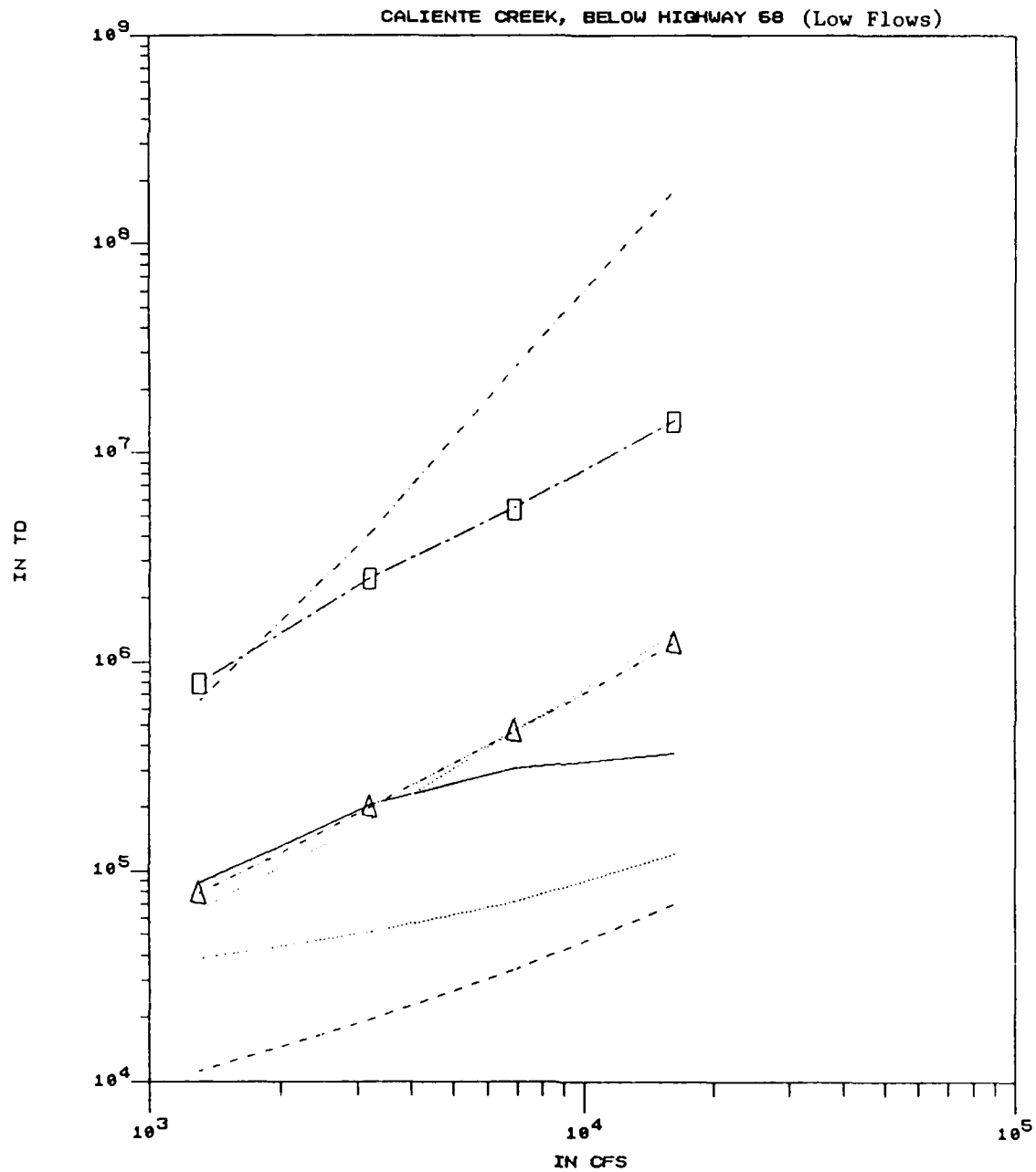




## **APPENDIX D**

### **Sediment-Discharge Rating Curves**

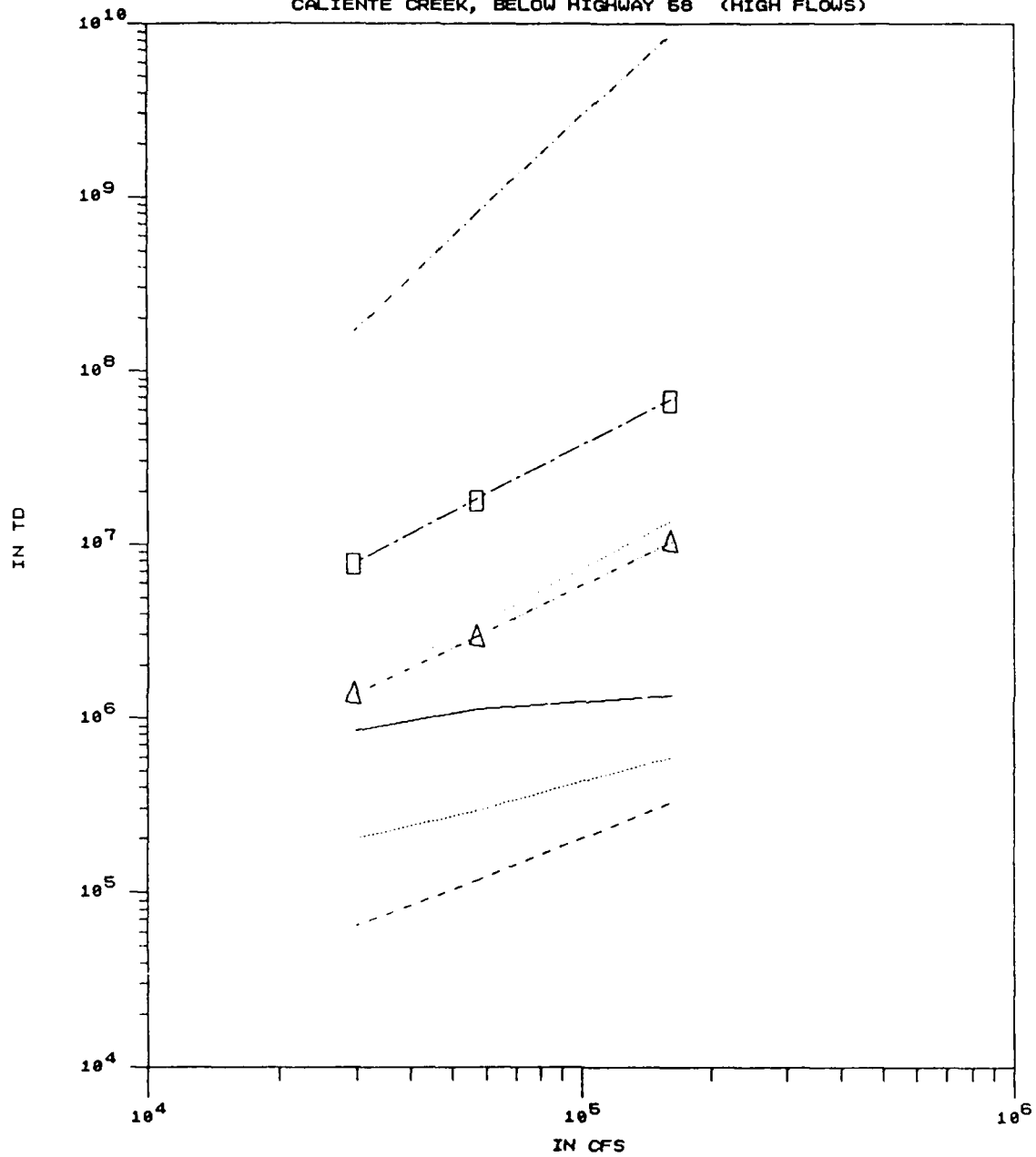
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YANG SEC 200	8 NOV 89	5PM	NEW LAURSEN(MADDEN) SEC 200	8 NOV 89	
ACKER-WHITE SEC 200	8 NOV 89	5PM	COPELAND LAURSEN SEC 200	8 NOV 89	5
COLBY SEC 200	8 NOV 89	5PM			

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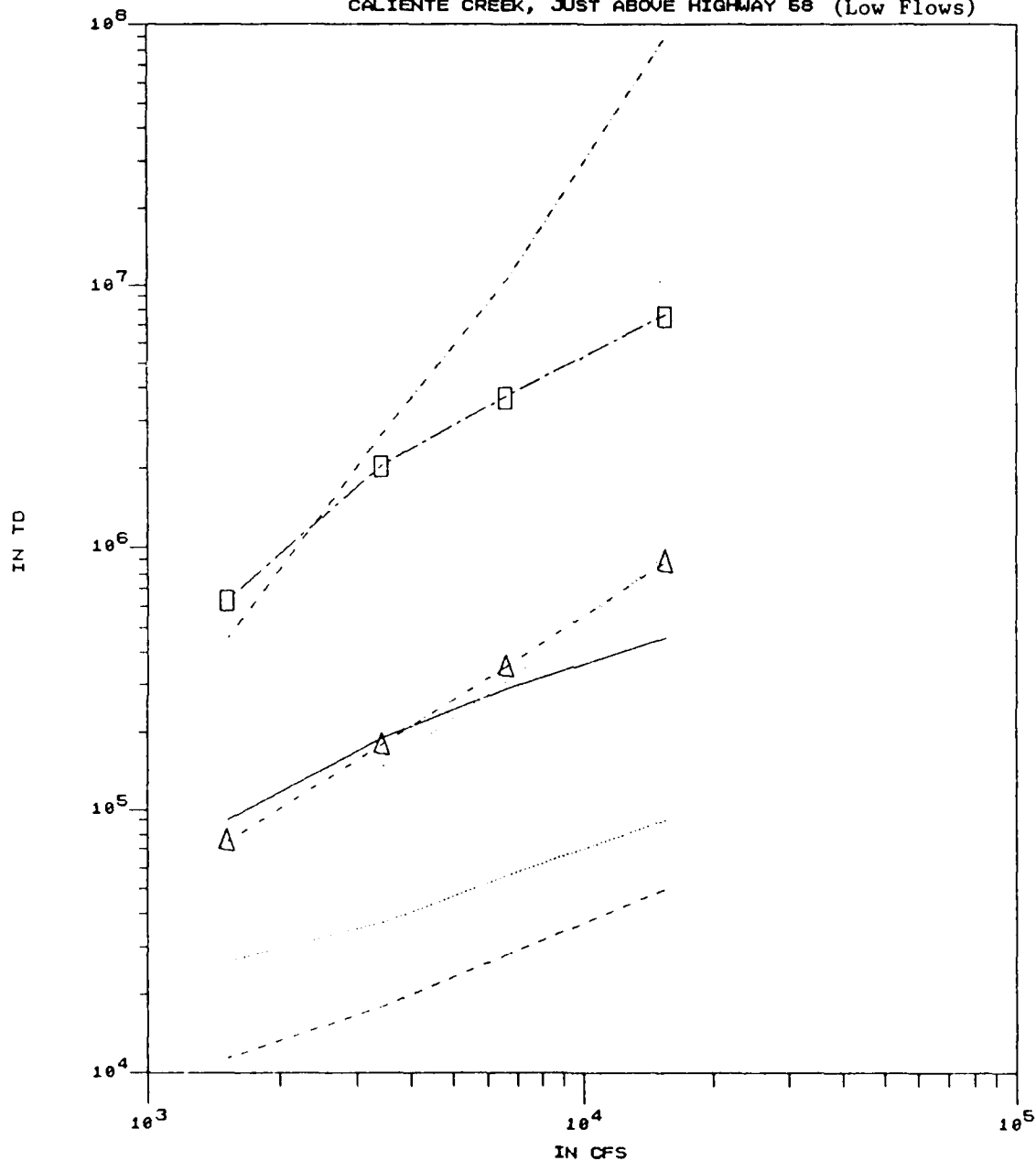
CALIENTE CREEK, BELOW HIGHWAY 68 (HIGH FLOWS)



—— TOFFALETI SEC 200 8 NOV 89 5PM	----- MPM(1948) SEC 200 8 NOV 89 5PM
YANG SEC 200 8 NOV 89 5PM	---△--- NEW LAURSEN(MADDEN) SEC 200 8 NOV 89
----- ACKER-WHITE SEC 200 8 NOV 89 5PM	---□--- COPELAND LAURSEN SEC 200 8 NOV 89 5
..... COLBY SEC 200 8 NOV 89 5PM	

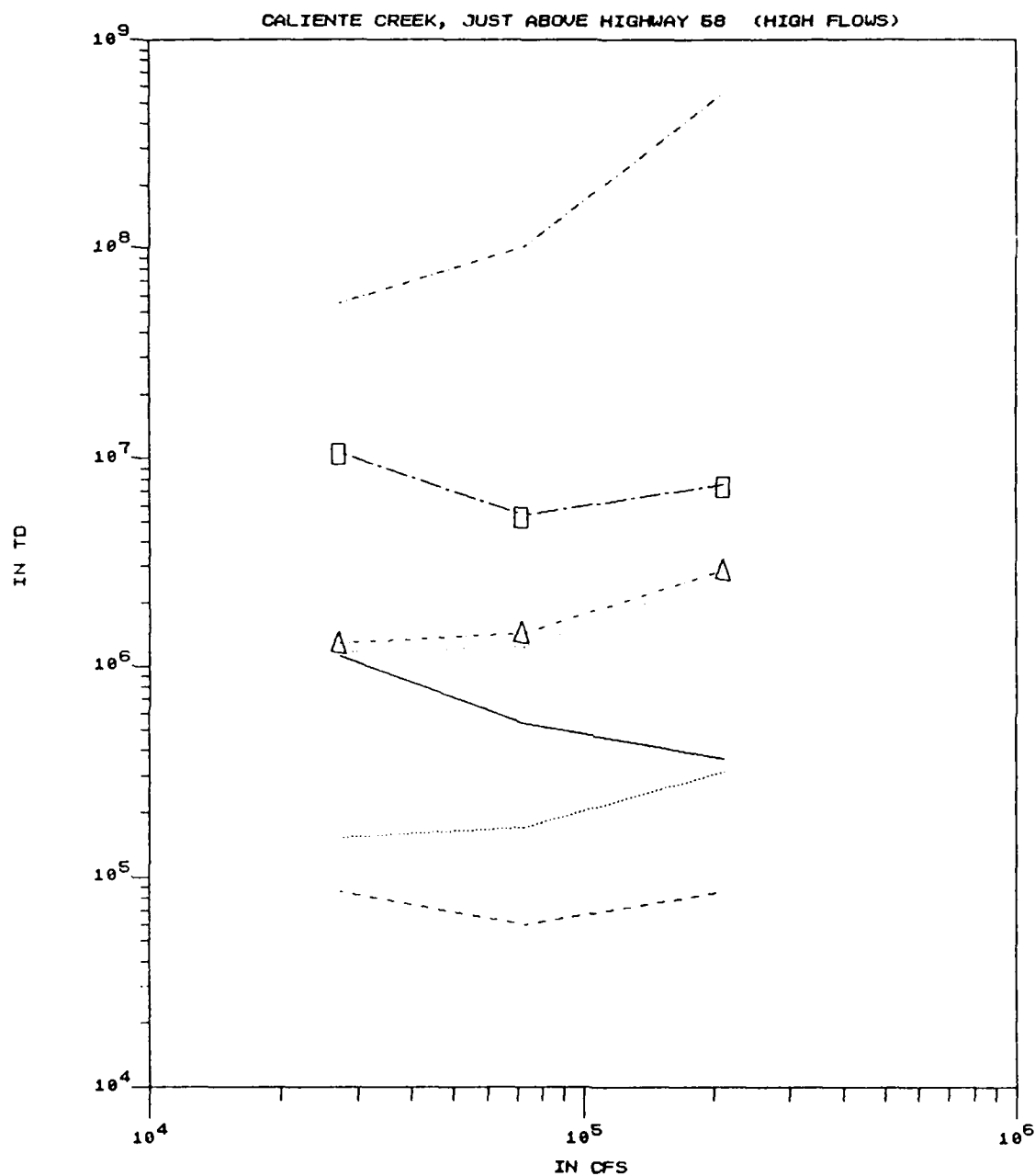
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CALIENTE CREEK, JUST ABOVE HIGHWAY 68 (Low Flows)



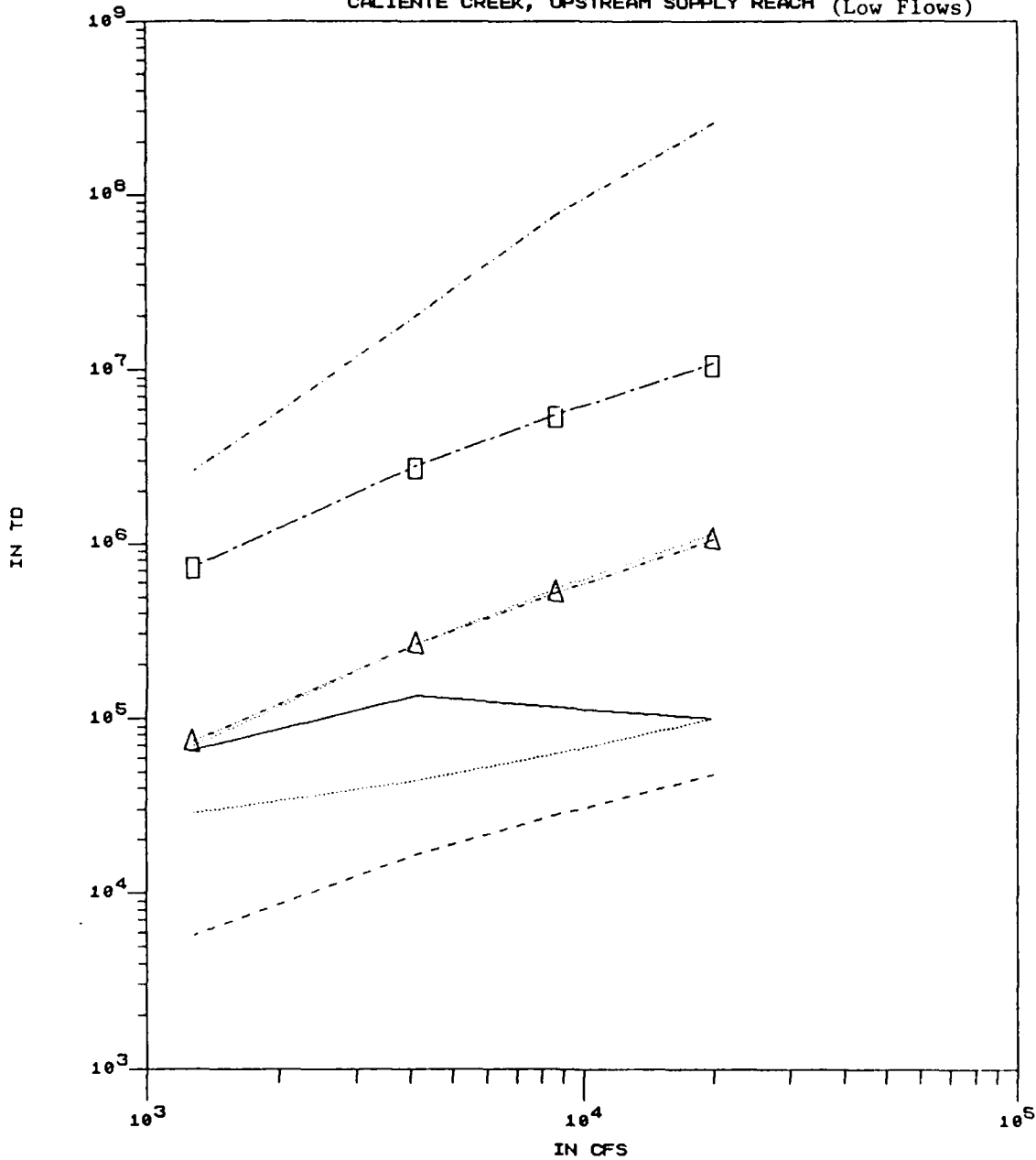
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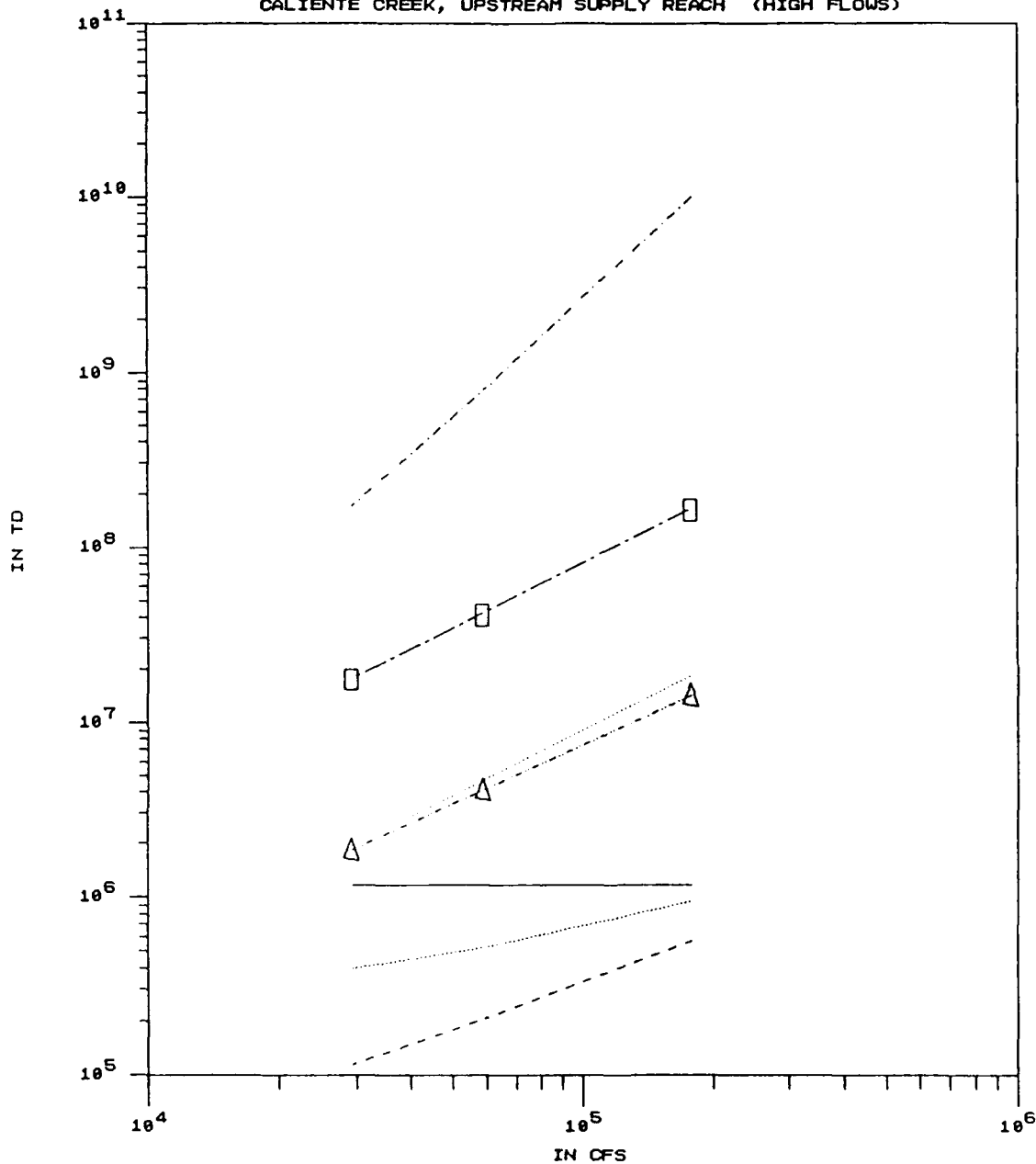
CALIENTE CREEK, UPSTREAM SUPPLY REACH (Low Flows)



TOFFALETI SEC 300 8 NOV 89 5PM  
 YANG SEC 300 8 NOV 89 5PM  
 ACKER-WHITE SEC 300 8 NOV 89 5PM  
 COLBY SEC 300 8 NOV 89 5PM  
 MPM(1948) SEC 300 8 NOV 89 5PM  
 NEW LAURSEN(MADDEN) SEC 300 8 NOV 89 5PM  
 COPELAND LAURSEN SEC 300 8 NOV 89 5PM

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CALIENTE CREEK, UPSTREAM SUPPLY REACH (HIGH FLOWS)



———— TOFFALETI SEC 300	8 NOV 89	5PM	----- MPM(1948) SEC 300	8 NOV 89	5PM
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----- ACKER-WHITE SEC 300	8 NOV 89	5PM	-----□----- COPELAND LAURSEN SEC 300	8 NOV 89	5PM
--- COLBY SEC 300	8 NOV 89	5PM			

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION / AVAILABILITY OF REPORT		
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Project Report No. 13			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION Hydrologic Engineering Center		6b. OFFICE SYMBOL (If applicable) CEWRC-HEC	7a. NAME OF MONITORING ORGANIZATION Water Resources Support Center		
6c. ADDRESS (City, State, and ZIP Code) 609 Second Street Davis, California 95616			7b. ADDRESS (City, State, and ZIP Code) Casey Building 2594 Fort Belvoir, Virginia 22060		
8a. NAME OF FUNDING / SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code)					
			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
11. TITLE (Include Security Classification) Phase I Sediment Engineering Investigation of the Caliente Creek Drainage Basin FINAL REPORT					
12. PERSONAL AUTHOR(S) Dr. Robert C. MacArthur					
13a. TYPE OF REPORT Project Report		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) June 1990	
15. PAGE COUNT 57					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Alluvial Fans; Sediment Production; Sediment Yield; Transport Capacity; Geomorphology; Single Event Analyses; Episodic Flows, Average Annual Sediment Yield, (continued)		
FIELD	GROUP	SUB-GROUP			
19. ABSTRACT (Continue on reverse if necessary and identify by block number)  This report summarizes the procedures used for computing the basinwide annual yields and single event sediment production for ephemeral channels located on an incised alluvial fan in Central California. Unique geomorphic characteristics of the basin and alluvial fan are discussed in light of data and analytical methods necessary to compute sediment delivery and yield at a proposed damsite. )					
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				22c. OFFICE SYMBOL CEWRC-HEC	



18. SUBJECT TERMS (Continued)

Flow Duration and Regional Methods.